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State Geological and Natural History Survey
BULLETIN No. 18

TRIASSIC FISHES
OF CONNECTICUT

By
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Professor of Paleontology at the University of Pittsburgh, and
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CHARLES ROCHESTER EASTMAN, Ph.D.
Professor of Paleontology at the University of Pittsburgh, and Curator in charge of Fossil Fishes at the Carnegie Museum

"Die Weisheit ist nur in der Wahrheit."—*Goethe.*

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TRIASSIC FISHES OF CONNECTICUT.

I.

ON THE STUDY OF FOSSIL FISHES IN GENERAL.

"There will we find laws which shall interpret,
Through the simpler past, existing life."—
Kingsley.

PALEONTOLOGY is the natural history of the Past. It is that branch of biological science which acquaints us with the endless succession of animate forms that has inhabited the earth since life first began. Primarily an extension of zoology and botany, as these subjects are commonly understood, it may be regarded also as an historical science, by virtue of the time element pervading it. Its aims and methods are akin to the historian's. The facts it deals with are vital facts, linked together by the principle of continuity and progressive development. The story it unfolds is one of world-wide changes, of silent, slow, and exceedingly gradual transformations wrought upon organic framework by an infinity of complex forces, strivings, tendencies, surroundings, all operating through immense cycles of time, and culminating finally in one supreme achievement — in the production of a race of beings possessed of self-conscious intelligence, and of a well-nigh unlimited development of that faculty.

The historical aspect of paleontology is worth considering. What is the theme of human history, if it be not the development of mankind? Is it not a record of all the changes in the state of men which have occurred since the first evidences of "the sons of men" upon our globe? Does it not, in a word, inform us of the *progression* of human events? The theme of paleontology is similar, but broader. It is compassed by, and at the same time extends, the domain of universal history. It treats of the development of life in general, considers it in its *grandes lignes,*

in all its manifold manifestations. It is the record of all the changes and progressive modifications that have taken place among organic forms since their first appearance in remote geological antiquity. It seeks to ascertain the value of various adjustments to external conditions, of improvements in mechanical contrivances and other factors making for an advance; and, in tracing this line of progress, it aims to assign to different groups, or to different grades of the same group, their proper position and relative importance in the scheme of upward transformation.

If the mystery of the beginning of all things must forever remain insoluble for us, as Darwin with his life-work behind him was obliged to admit,[1] paleontology at least dispels for us some of the obscurity of former geological cycles, during which life existed on our planet and left memorials of its infinitely slow progress along the road to perfection. Perfection, that is, in the Darwinian sense: meaning the production of the higher animals, and their capacity for psychic advance. An impressive spectacle this; no one can contemplate it seriously without feeling the sense of that infinity in contrast with which a man recognizes his own finitude. Then it is that one feels in accord with Keats' view:

> "Stop and consider! life is but a day;
> A fragile dew-drop on its perilous way
> From a tree's summit; a poor Indian's sleep
> While his boat hastens to the monstrous steep
> Of Montmorenci. . . . "

It is not only a just, but a truly ennobling conception to regard paleontology as an extension of human history. "*La science des sciences, c'est donc la science de l'homme,*" Montaigne aptly remarks. Would we comprehend our own nature, and seek to know what man in his essence really is, what he has been, whence he came, whither bound, what destiny he may achieve, and, finally, what value attaches to his mortality — to acquire this self-knowledge we must study that larger nature of which man forms so insignificant a part. The soul grows in knowledge of itself as it realizes the contrast with the grandeur, the sheer massiveness of nature, and the eternity of the hidden forces

[1] Life and Letters of Charles Darwin, edited by Francis Darwin.

which are now and ever have been at work re-shaping the world since the very foundation of being. Knowledge of this sort vastly enlarges our consciousness, gives to our mortality a setting and perspective, dilates the mind and elevates the spirit by forcing them to range widely over the realm of universal history. It also enables us to form a relative estimate of ourselves and our career by applying a larger scale of life — the scale of infinity. Clearly, therefore, the humanistic interest of paleontology is very great; and considerations of this nature help determine the value of any science quite apart from questions of practical utility. In every science there may be a twofold yield; one that is expressed in material values, and another that is interpreted in terms of the spirit. Returns of both kinds are worth striving for.

But, it may be objected by some, the facts of paleontology can at best only remotely affect our traditional outlook upon life. For those who are satisfied merely with the assembling of facts, and look no further than a connection between them, without being able to comprehend the life of thought in general, this objection may hold. But the thoroughgoing inquirer insists not merely upon an accumulation of dead knowledge; his mind aims at an interpretation of the results of investigation, and attaches to these things meanings and values. So far as relates to human or universal history, the supreme value lies in *understanding* what has happened, in perceiving the meaning of events, in grasping the principles and laws that govern organic and social evolution. For this purpose the past must needs be reconstructed by means of the trained imagination out of all available data. The more vigilant the imagination, the better historian, and the better scientific investigator, other things being equal; for to the well-trained explorer in any science this faculty is never a hindrance, but a positive advantage. Obviously, if one lacks the power of transporting himself into the past, one can understand nothing of the past. But once that mental journey accomplished, and so soon as we acquire the habit of looking at experience objectively, without immediate relation to our own time and place, then, in the words of an English historian (Bury), "the modern age falls into line with its predecessors and loses its obtrusive prominence, and we come to

see our petty periods *sub specie perennitatis.*" World-facts contemplated in this way help us, so says yet another historical writer (Villari), to " gain a new consciousness of our own being, and to win deeper insight into recesses of our own nature."

The essayist just quoted gives it as his opinion that the history of the whole universe is required to explain the individual man, " because," as he says, " more or less transformed, all history lives in us human beings. Therefore, as it lives in us all, why should we marvel at our power of transporting ourselves back into past times and living once more in them? In studying the history of Greece, we not only read the tale of a vanished past, but also that of a society and of a civilization that, although transformed, still endures within us as a constituent element of our mentality. Thus we are reading the history of a part of ourselves, and gain a clearer appreciation of that part on seeing it developed, magnified, and surrounded with its pristine glory, as it first flashed upon the world through the deeds of the Grecian people. . . . Thus in reading universal history we learn to recognize the process by which our own intelligence has been gradually built up. It has been justly remarked that, even as the geologist can trace the history of the transformations of the globe from any chance handful of earth, so too the philologist, on analyzing some phrase you have uttered, will find in it the record of the transformations of tongues."[1]

It is an obvious truism that to every man the world as he sees it depends on his physical organization and upon the way he has been taught to look at it through education and years of experience. But the scientific conception of the world and of the value and meaning of life has become profoundly modified within comparatively recent times through the influence of reorganizing ideas. Men in all ages have shown the keenest interest in the problems of man's origin and past development. The first great step in advance was made by the shores of the Ægean more than two thousand years ago. But the positive results of ancient philosophy were inadequate and limited, as compared with modern, because of its more limited resources. After the time of the Greek poets and philosophers, more than two milleniums were to pass away before those new reorganizing

[1] Villari, Pasquale, Studies Historical and Critical, 1907, p. 37 ff.

ideas — those which include the principle of continuity and the higher principle of development — became effectual in the world of thought, and enlightened mankind through the medium of Darwin's utterances. Both in history and in natural science the spirit of investigation was completely transformed by these ideas.

So much by way of parenthesis. Enough has now been said to show that the natural history of the past possesses rich interest from a culturo-historical or humanistic standpoint. And from these matters we pass on to a consideration of our special theme, the study of fossil fishes in general. Before speaking, however, of the introduction and succession of the class of fishes in point of chronological sequence, it may be useful to insert at this point a table showing the principal divisions of the stratigraphic column, which will serve the double purpose of indicating the position of our Triassic rocks in the system, and marking the advent of successively higher classes of vertebrates. Formational units, it is to be observed, are divided into systems, series, and groups; and the corresponding time-relations are expressed by the terms eras (or ages), periods, and epochs. Following is the commonly accepted arrangement:

GEOLOGICAL TIME-SCALE.

Eras	Periods	Life
Cenozoic	Quaternary	Man
	Tertiary	Mammals the dominant class
Mesozoic	Cretaceous	Reptiles dominant throughout era
	Jurassic	Birds appear
	Triassic	Earliest mammals
Paleozoic	Carboniferous	Amphibians the dominant class
	Devonian	Fishes dominant
	Silurian	Invertebrates still dominant
	Ordovician	Fishes appear
	Cambrian	Leading groups of invertebrates
Archæan		Scanty and indistinct organic remains

The Cambrian system, at the base of the Paleozoic, has thus far failed to yield any indication of the presence of backboned creatures. Neither Chordates nor "Protochordates," that is, primitive forerunners of the vertebrate phylum, make their appearance in the geological time-scale until the Ordovician, after which they continue sparsely throughout the Silurian. From what lower group of organisms the primitive progenitors of the vertebrate stem were descended, and during what period the hiatus between diverse phyla was bridged over, we have no means of knowing. The absence of transitional forms, or indeed even of Protochordates, in strata anterior to the Ordovician is not a very significant fact, when it is considered that the primitive forerunners of chordate animals were probably soft-bodied, and therefore incapable of preservation in the rocks. Although numerous indications of fish-like vertebrates have been obtained at different localities both in this country and abroad, as, for instance, from the Ordovician of Colorado, Montana, and Scotland, it is not until the Silurian that their remains are found satisfactory enough for discussion. The dominant forms of fish life that we are acquainted with from rocks of this age belong to the lowly group of Ostracophores — creatures which differ from Fishes proper to such an extent that they are usually included in a separate class (Agnatha). They have incompletely formed jaws, are destitute of paired fins, and are without calcified endoskeletal parts (Fig. 1). On the other hand, as their name implies, they are protected by a shell-like external covering, whose elaboration can be traced through a number of successive stages. Toward the close of the Devonian they become entirely extinct, without leaving descendants.

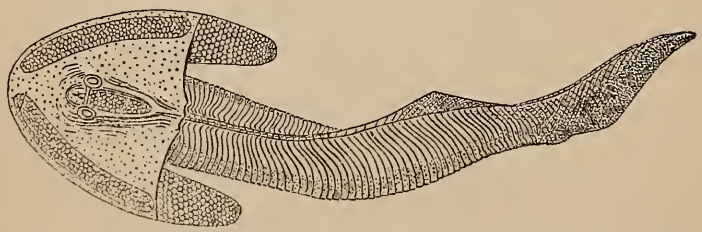

FIG. 1. *Cephalaspis murchisoni* Egerton. Lower Old Red Sandstone; Herefordshire. Head-shield seen from above, tail twisted to show dorsal fin and heterocercal tail mainly in side view. × ½ (after Smith Woodward).

Although forming the dominant feature of Silurian vertebrate life, Ostracophores are nevertheless accompanied in the

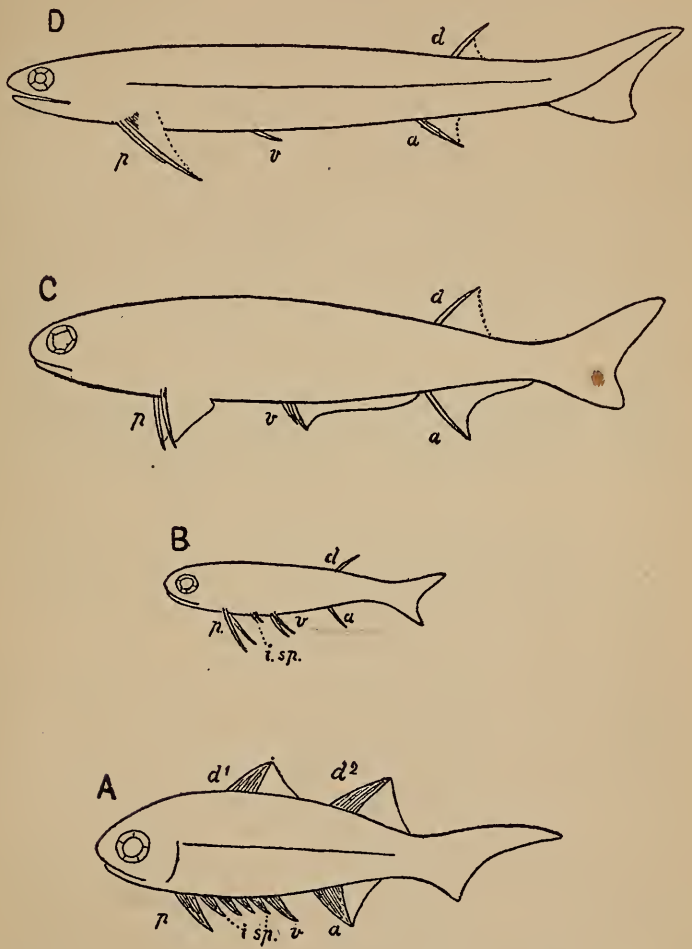

Fig 2. Outlines of Acanthodian Fishes, illustrating their gradual elongation in shape and loss of intermediate spines during successive periods. A, *Climatius scutiger* Egerton. Lower Old Red Sandstone; Scotland. B, *Mesacanthus mitchelli* (Egerton). *Ibid.* C, *Acanthodes sulcatus* Agassiz. Lower Carboniferous; Edinburgh. D, *Acanthodes gracilis.* Roemer. Lower Permian; Bohemia. *a,* anal fin; *d,* dorsal fin; *i. sp.,* intermediate spines; *p,* pectoral fins. (From Smith Woodward, partly after Traquair and Fritsch.)

latter part of that system by creatures which surpass them in grade, and are perfectly recognizable as true fishes, possessing as they do ordinary jaws and two pairs of lateral fins. These oldest remains of typical fishes — they are called Acanthodians after the name of the first described genus — are probably to be regarded as Elasmobranchs, and evidently have not diverged very far from the primordial stock which gave rise not only to the line of sharks and rays, but also to different grades of higher fishes. Acanthodians (Fig. 2) are a long-lived race, continuing throughout the Paleozoic. An allied primitive tribe that was less successful, and by reason of its long-bodied form is regarded by some writers (Woodward) as senile, is that typified by *Cladoselache* (Fig. 3), which is known from the late Devonian.

FIG. 3. *Cladoselache fyleri* Newberry. Cleveland shale (Upper Devonian); near Cleveland, Ohio. Right lateral aspect, about one-tenth natural size. A primitive shark, illustrating the simplest kind of paddle-fins, which are supported by nearly parallel bars of cartilage (after Bashford Dean).

During the Devonian appeared two large groups of fishes with paddle-shaped fins. These groups are commonly known as Lung-fishes and "fringe-finned" Ganoids — Dipnoi and Crossopterygii they are technically called. Their geological history is peculiar. Both groups early acquired dominance, spread over all regions of the globe, and seem indeed to have culminated in the Devonian, being numerically and specifically more abundant during that period than at any subsequent epoch. Only two modern survivors of Crossopterygii are known from African rivers (*Polypterus* and *Calamoichthys*). Of the long and archaic line of Lung-fishes represented by *Dipterus* (Fig. 4) and its associates in the Devonian, only the most generalized Ceratodont type, represented nowadays by but three fresh-water genera, has been able to persist until our own time. That the Ceratodont type has had a continuous existence since the early Paleozoic follows as a logical necessity from regarding the Dipterine group

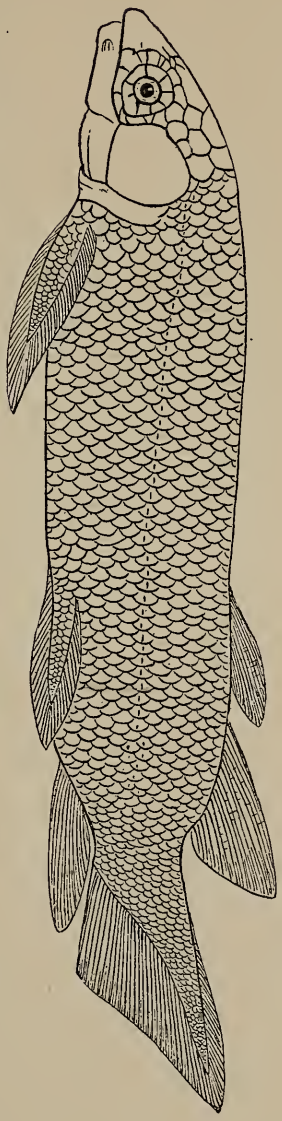

Fig. 4. Restoration of *Dipterus valenciennesi* from the Scottish Old Red Sandstone. × ½ (after Traquair).

as a specialized derivative. Recently described remains of *Protopterus* from the African Tertiary present an astonishing likeness to *Sagenodus,* as regards the dentition.

Yet another group of fishes, representing a still higher grade than any of the foregoing, makes its first appearance during the Devonian, but does not begin to acquire dominance until the Carboniferous. This is the great group of Actinopterygians or "ray-finned" fishes, to which by far the greater number of modern forms belong. From the Devonian onward until the close of the Permian, this higher grade of fishes was represented by a single family of primitive Chondrostei, whose degenerate descendants finally passed over into modern Sturgeons. It is probable that the short-lived family of the Catopteridæ, which gained a wide distribution in the Trias, is an offshoot of the tribe of primitive Sturgeons; and it is noteworthy that the decline of the latter began simultaneously with the rise of the next higher suborder, or Protospondyli. No links are known connecting this suborder with the Chondrostei, hence in the present state of our knowledge, the Sturgeon tribe and the Protospondyli are distinctly demarcated. During the Trias the Protospondyli are represented by the important and truly cosmopolitan family of Semionotidæ, which, with the previously mentioned Catopteridæ, form the chief constituents of our local Triassic fish fauna. The only modern representatives of this suborder are the bow-fin and garpike (*Amia* and *Lepidosteus*), both confined to the fresh waters of North America, and exhibiting the long-bodied shape of senile or decrepit derelicts.

Associated with members of the preceding suborder (Protospondyli) in rocks of the Upper Trias are found a few fishes having a remarkably modern aspect, and characterized not only by a complete vertebral column, but also by a simplified lower jaw, which consists of but two pieces on each side. The forerunners of the Isospondyli, as this suborder is called in allusion to the circumstance that the vertebræ are simple, without being fused into a group behind the head, scarcely differ in grade from the modern herring tribe. Among typical representatives may be mentioned the genera *Pholidophorus* and *Leptolepis,* ranging throughout the Triassic and Jurassic. The group displays rather feeble vigor until the beginning of the Cretaceous, when it

rapidly multiplied, became dominant, and replaced the Protospondyli. Living members of the suborder belong to that division of bony fishes known as physostomous Teleostei.

One of the late Professor Beecher's generalizations, which seems to hold true throughout the animal kingdom, is that spines characterize only the latest representatives of the class. Applying this to the class of Pisces, Dr. Smith Woodward remarks: "The Acanthopterygii ("spine-finned") are thus the highest and latest fishes of all, though they sometimes eventually descend from their high estate by degeneration. They exhibit all the peculiar changes in the skull, upper jaw, and pelvic fins noticed as first appearing in a variable manner in the Cretaceous Isospondyli. The spiny-finned fishes began by Berycoids and possibly Scombroids in the Chalk, closely resembling, but not identical with genera living at the present day. By the Eocene period, however, nearly all the modern groups of Acanthopterygii had become completely separated and developed, and their sudden appearance is as mysterious as that of early Eocene mammals."

The same eminent authority also recapitulates the main outlines of the evolutionary history of fishes in the following passage:[1]

"Fossils prove that the earliest fish-like organisms strengthened their external armour so long as they remained comparatively sedentary; that next the most progressive members of the class began to acquire better powers of locomotion, and concentrated all their growth-energy on the elaboration of fins; that, after the perfection of these organs, the internal bony skeleton was completed at the sacrifice of the outer plates, because rapid movement necessitated a flexible body and rendered external armour less useful; that, finally, in the highest types the vertebræ and some of the fin-rays were reduced to a fixed and practically invariable number for each family and genus, while there was a remarkable development of spines. As survivors of most of these stages still exist, the changes in the soft parts which accompanied the successive advances in the skeleton can be inferred. Hence palæontology furnishes a sure basis for a

[1] Woodward, A. S., The Relations of Palæontology to Biology. *Ann. Mag. Nat. Hist.*, 1906, ser. 7, xviii, p. 314.

natural classification in complete accord with the development of the group."

Concerning the matter of classification, it need only be remarked that Pisces proper are divided into four subclasses, all of which have enjoyed a continuous history from the early Devonian onward to the present day. These subclasses are known under the following designations: (1) The Elasmobranchii, including modern sharks and rays; (2) Holocephali, or Chimæroids; (3) Dipnoi (Dipneusti), or Lung-fishes; and (4) Teleostomi, including ganoids and modern bony fishes. Only the last-named of these grand divisions is represented in the Triassic rocks of the Atlantic border region, and of the two orders embraced by it, the first (Crossopterygii) is represented by a solitary family and genus, and the second (Actinopterygii) by five genera belonging to three different families. The taxonomic relations of these families and genera are graphically illustrated in the following scheme: —

Subclass	Orders	Suborders	Families and Genera
Teleostomi	Crossopterygii	Actinistia	Cœlacanthidæ 1. *Diplurus*
	Actinopterygii	Chondrostei	Catopteridæ 2. *Catopterus* 3. *Dictyopyge*
		Protospondyli	Semionotidæ 4. *Acentrophorus* 5. *Semionotus*
			Eugnathidæ 6. *Ptycholepis*

It will be seen from the foregoing table that the fauna with which we have to deal is relatively undiversified, and consists of surprisingly few elements as compared with contemporaneous fish faunas of other regions. The inference to be drawn is that these peculiarities are in all likelihood dependent upon the nature of the environment — that is to say, upon the absence of marine conditions over the area inhabited by this fauna. The evidence

which compels us to regard the sediments in question as a non-marine facies of the Trias does not proceed primarily from the fossil fishes themselves. On the contrary, the North American species of *Semionotus, Ptycholepis,* and *Diplurus* are so closely affiliated with European "geminate types," to employ Jordan's term,[1] which occur in the marine Trias, that it is impossible to suppose that there were any great physiological differences between them. Hence there would be no reason in the absence of other evidence to believe that that they were adapted to a different habitat.[2].

While there is nothing in the character of the fossil fishes which would prove conclusively whether the deposits were formed in salt or brackish or fresh water, the physical character of the deposits and the fossils other than fishes found in them make it substantially certain that the deposits are not marine.[3] No corals, echinoderms, or brachiopods have been found in the Triassic in Connecticut or in any other of the Triassic basins of eastern North America. Mollusks are very few, and most of those found are undoubtedly fresh-water forms. A very few marine mollusks, it is claimed, have been found in the Triassic of Pennsylvania. A few crustacea, probably fresh-water or brackish-water forms, have been found in some of the southern Triassic basins, though not in Connecticut. A few insect larvæ have been found. For the rest the fossils of the formation consist of land plants and tracks of reptiles and amphibians, with a few skeletons of reptiles. Such an assemblage of fossils makes it clear that the formation is not marine, though the presence of a few marine shells (if those shells are rightly identified) indicate conditions in part estuarine.

Until recently the opinion has been generally held that the deposits of the Triassic of eastern North America were formed in tidal estuaries whose waters for the most part were brackish or nearly fresh. It seems probable, however, that the deposits

[1] Jordan, D. S., The Law of Geminate Species. *Am. Nat.,* 1908, xlii, pp. 73-80.

[2] De-Alessandri remarks as follows regarding the conditions under which the strata at Besano were deposited: "I caratteri litologici infatti dimostrano come i depositi costituenti la formazione raibliana di Besano debbono in parte ascriversi ad azione organica e che essi si costituivano poco lungi dalle coste. E l'esame della sua ittiofauna . . . . conferma appunto la natura costiera del giacimento."

[3] Rice and Gregory, Manual of the Geology of Connecticut, pp. 166-179 (State Geol. and Nat. Hist. Surv., Bull. 6.)

were not formed in continuous water bodies coextensive with the areas occupied by the deposits; but that they include confluent alluvial fans formed by torrents descending from the mountain walls at the margin of the area, fluvial deposits formed by rivers migrating over the lowland, lacustrine deposits in places where the drainage was obstructed, with probably estuarine deposits in parts of the area that were covered by tidal waters, and very likely eolian deposits over parts that were dry land. Geologists have recently come to appreciate the importance of such "continental" deposits.[1]

We have next to consider the question of the position occupied in the series of Triassic rocks by the fish-bearing beds in the local section, and also the ancillary query as to the contemporaneity of deposits in the Connecticut Valley and the New York-Virginia basin. For a solution of these problems extended comparisons are necessary with related faunas of other regions, wheresoever they may be found; and, as this phase of the discussion has received very little attention heretofore, we may be permitted to inquire into the matter somewhat fully. This will be the object of the following section.

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[1] J. V. Lewis, Origin and Relations of the Newark Rocks, pp. 102-108 (Geol. Surv. N. J., Ann. Rept. for 1906). W. M. Davis, The Triassic Formation of Connecticut, pp. 29-34 (18th Ann. Rept., U. S. Geol. Surv., Part ii). J. Barrell, Mud-cracks as a Criterion of Continental Sedimentation (*Journ. of Geol.*, xiv. pp. 524-568). In connection with these writings one may consult several recent articles by J. Lomas who interprets the British Trias as "filled-in desert lakes" (*Proc. Liverpool Geol. Soc.*, 1907, p. 183); also the Trias Reports of the British Assoc. Adv. Sci.; and Professor Bonney's paper On the Origin of the Trias (*Proc. Yorkshire Geol. Soc.*, 1906, xvi, p. 1).

II.

GEOLOGIC CORRELATION OF THE CONNECTICUT VALLEY FISH-BEARING BEDS.

The general consensus of opinion among geologists who have studied the Triassic rocks of eastern North America is that the sediments were deposited more or less contemporaneously in a number of isolated basins or troughs, these depressions occurring at intervals (rather than extending continuously) along the Atlantic border from Nova Scotia to South Carolina. As to the period of deposition represented by these sediments, in the opinion of the best authorities they are referred to the uppermost division of the Triassic system, that which in European geology is termed the Keuper. This opinion, be it observed, has rested hitherto almost exclusively upon the evidence of paleobotany. And not unnaturally, owing to the prevailing dearth of marine invertebrates, which always afford the most reliable indication of the age of strata.

In view of the almost total absence of the latter class of fossils, it is pointed out by Professors Rice and Gregory in their "Manual of the Geology of Connecticut" (p. 182), that the best paleontological evidence for purposes of correlation which is here available is that "afforded by comparison of the fossil plants, which occur abundantly in some areas of the formation, particularly in the Richmond area, with the fossil plants of some of the European strata." The results of such comparison show, as stated by these authors, "that the flora of these sandstones finds its nearest equivalent in that of the Keuper, the uppermost division of the European Trias. The indications afforded by the fishes and reptiles, though more scanty, are in harmony, so far as they go, with the evidence of the plants." In like manner Professor Lester F. Ward, writing in 1891, expressed the view that the flora of the New York-Virginia area fixes the horizon of the so-called "Newark formation" "with almost absolute

certainty at the summit of the Triassic system, and narrows the discussion down chiefly to the verbal question whether it shall be called Rhaetic or Keuper. . . . . The beds that seem to be most nearly identical, so far as the plants are concerned, are those of Lunz, in Austria, and of Neue Welt, in Switzerland. These have been placed by the best European geologists in the Upper Keuper. Our American Trias can scarcely be lower than this, and it probably cannot be higher than the Rhaetic beds of Bavaria."[1]

Professor J. S. Newberry reached a similar conclusion in regard to the homotaxial relations of the "Newark" series of the Atlantic border region,[2] but it is rather singular that his reference of these beds to the uppermost Trias was based almost entirely upon the evidence furnished by fossil plants, whereas that afforded by the fishes was in part neglected, in part misinterpreted. This accomplished student of paleichthyology was clearly in error, as will presently appear, in supposing that the fishes of the Newark system are "not nearly related to those of any European formation," and he failed even to recognize the identity between the so-called "*Ischypterus*" of Egerton and Agassiz's genus *Semionotus*.

As early as 1850 Professor Louis Agassiz declared that in his opinion the fossil fishes from the Virginia coal field, and "from the so-called New Red Sandstone [of New Jersey and New England], indicate an age intermediate between the European New Red and the Oolite."[3] Subsequently he modified this view so far as to state that the fossils in question are the equivalent neither of the Triassic fishes of southern Germany, nor of those from the English Lias, wherefore he referred the

[1] Ward, L. F., The Plant-bearing Deposits of the American Trias. *Bull. Geol. Soc. Am.*, 1891, iii, pp. 23-31.— Idem, Principles and Methods of Geologic Correlation by means of Fossil Plants. *Am. Geol.*, 1891, ix, pp. 34-47.

Writing three years earlier than Professor Ward, the Austrian geologist, D. Stur, concluded from the evidence of fossil plants that the Virginia coal-field area is the precise equivalent of the German Lettenkohle, which, according to some geologists, immediately underlies the Keuper, while by others it is regarded as the lowest division of the Keuper, just as the Rhaetic is sometimes incorporated with the Keuper as its uppermost member. The title of his paper is as follows: "Die Lunzer- (Lettenkohlen-) Flora in den 'older Mesozoic beds of the Coalfield of eastern Virginia.'" *Verh. Geol. Reichsanst.*, 1888, no. 10, pp. 203-217.

[2] Newberry, J. S., The Fauna and Flora of the Trias of New Jersey and the Connecticut Valley. *Trans. N. Y. Acad. Sci.*, 1887, vi, pp. 124-128.

[3] Agassiz, L., *Proc. Am. Assoc. Adv. Sci.*, 1850, iv, p. 276.

Newark rocks to a time interval between the Trias and Lias, for which there is no corresponding European expression.[1]

Most recently of all it has been claimed by the present writer,[2] in contrast to the views of Agassiz and Newberry, that the Newark fish fauna of the Atlantic border region does, in reality, manifest rather close relationship to those of certain European formations; and in particular that a marked correspondence exists between it and the assemblage that is known from the topmost member of the Alpine Muschelkalk — that is to say, the summital portion of the Middle Trias as developed in the Mediterranean region. The precise horizon from which the foreign assemblage in question has been obtained is the so-called Perledo limestone, on the eastern verge of Lake Como, in Lombardy, and usually correlated with the base of the Buchenstein beds.[3] By some authors the latter are referred to the base of the Ladinian, by others — and these would seem to be in the minority — to the summit of the Virglorian (zone of *Ceratites trinodosus*). Under these names, Ladinian and Virglorian, are understood respectively the upper and lower members of the Alpine Muschelkalk, where, as is well known, a threefold division such as characterizes the deposits of Germany north of the Alpine region is not observable.[4] The position of the Buchenstein limestone, and also of the higher (Keuper) fish-bearing beds of Besano, Raibl, Seefeld, etc., as compared with the Anglo-German Trias, is shown in the subjoined table. This is constructed more especially after the writings of Baron F. von Huene on the British, and those of Professors Haug, Arthaber and others on the Alpine Trias.[5]

[1] Agassiz, L., *Proc. Am. Acad.*, 1852-57, iii, p. 69.

[2] *Geol. Surv. N. J.*, Ann. Rep. for 1904 (1905), pp. 70, 72.

[3] A convenient geological guide for the Como section will be found in chapter 1 of Dr A. Tornquist's "Führer durch das oberitalienische Seengebirge," forming volume 9 of the *Sammlung geologischer Führer* (Berlin, 1902).

[4] "Le Trias moyen comprend, comme on sait, deux étages: le Virglorien Ren. (= Recoarien Bittn., Anisien Mojs., Waag., Dien.), et le Ladinien Bittn."— E. Haug, in *Bull. Soc. Géol. France*, 1906, ser. 4, vi, p. 368.

[5] A generalized section of the Alpine Trias is given at page 254 of G. von Arthaber's treatise, incorporated with the second part of Frech's "Lethæa Geognostica" (Heft 2, 1905), and a more detailed section of the Como district at page 399 of the same work. Heft 1 of this volume contains an introduction, by the editor, to the study of the Mesozoic and Trias, and a description of the Continental Trias by E. Phillippi in collaboration with other authors (1903). See also the following by F. von Huene: "Eine Zusammenstellung über die englische Trias und das Alter ihrer Fossilien. *Centralbl. f. Mineral. Geol. Pal.*, 1908, pp. 9-17. A slightly different arrangement is indicated in the table given at p. 29 of G. De-Alessandri's memoir on the Triassic Fishes of Lombardy, 1910.

CORRELATION SCHEME OF ANGLO-GERMAN AND ALPINE TRIAS.

TRIAS	GREAT BRITAIN	GERMANY	ALPINE REGION
	Rhaetic	Rhaetic	Rhaetic
Upper	Keuper marl (Upper Keuper sandstone)	Upper, Middle, Lower } Keuper	Alpine Keuper { Hauptdolomit (Steinmergelkeuper) [1]; St. Cassian beds; Raibl beds (Salzkeuper) [2]
Middle	Lower Keuper sandstone	Lettenkohle	Wengen Beds
		Upper, Middle, Lower } Muschelkalk	Ladinian (Buchenstein beds) [3]
Lower	Upper variegated sandstone; Pebble beds; Lower variegated sandstone (Bunter)	Upper, Middle, Lower } Buntsandstein	Virglorian; Werfenian (Werfen beds)

Since the earlier studies of the Perledo fish fauna by Bellotti and Deecke, the relations of some of its component elements have been more accurately determined by different spcialists, with the result that it is now possible to make more exact comparisons between the Lombardy fauna and our own Triassic fauna. The following revised list of species, which agrees in the main with a similar one compiled by De-Alessandri, takes into account all of the published writings on Lombardy fish remains.

REVISED LIST OF TRIASSIC FISHES OCCURRING IN THE LADINIAN (ALPINE MIDDLE TRIAS) OF PERLEDO, LOMBARDY.

Crossopterygii.

Family CŒLACANTHIDÆ.

1. *Heptanema paradoxum* Bellotti.

[1] Fish-bearing localities of Seefeld, Tirol; Hallein, Salzburg; and Giffoni, Italy.
[2] Fish-bearing localities of Besano, Lombardy; and Raibl, Carinthia (Austria).
[3] Fish-bearing locality of Perledo, on Lake Como, Lombardy.

Actinopterygii.

Family CATOPTERIDÆ.

2. *Perleidus altolepis* (Deecke).

Family BELONORHYNCHIDÆ.

3. *Belonorhynchus macrocephalus* Deecke (= *B. robustus* Bellotti MS.).

Family SEMIONOTIDÆ.

4. *Semionotus balsami* Bellotti.
5. *Colobodus* sp.
6. *Archæosemionotus connectens* Deecke.

Family MACROSEMIIDÆ.

7. *Ophiopsis lepturus* (Bellotti).
8. *Ophiopsis lariensis* De-Alessandri.

Family EUGNATHIDÆ.

9. *Eugnathus hermesii* (Bellotti).
10. *Eugnathus trotti* (Balsamo-Crivelli).
11. *Heterolepidotus pectoralis* (Bellotti).
12. *Heterolepidotus serratus* (Bellotti).
13. *Heterolepidotus taramellii* De-Alessandri.
14. *Heterolepidotus brevis* (Bellotti).
15. *Heterolepidotus* (?) *egidii-venantii* De-Alessandri.
16. *Heterolepidotus bellottii* De-Alessandri.
17. *Allolepidotus bellottii* (Rüppell).
18. *Allolepidotus nothosomoides* Deecke.[1]
19. *Allolepidotus rueppelli* (Bellotti).

Family PACHYCORMIDÆ.

20. *Urolepis macroptera* Bellotti.
21. *Urolepis microlepidota* Bellotti (including the so-called *U. elongata* Bellotti).

[1] The status of Deecke's genus *Allolepidotus* is open to some question. By Gorjanovic-Kramberger it is regarded as a subgenus of *Heterolepidotus*. Compare this author's memoir on "Die obertriadische Fischfauna von Hallein in Salzburg" (*Beitr. Paläont. u. Geol.*, 1905, xviii, p. 212).

Family PHOLIDOPHORIDÆ.

21. *Pholidophorus curioni* (Heckel).
22. *Pholidophorus oblongus* Bellotti.
23. *Prohalecites porroi* (Bellotti).
24. *Pholidopleurus* sp.

Family LEPTOLEPIDÆ.

25. *Leptolepis* sp.

It will next be in order to present a list of the species composing the Triassic fish fauna of the Atlantic border region in this country, for the purpose of comparison with the above. In this list the names of those species occurring in the Connecticut Valley area are denoted by an asterisk.

LIST OF FOSSIL FISHES OCCURRING IN THE "NEWARK" OR UPPER TRIASSIC ROCKS OF EASTERN NORTH AMERICA.

Crossopterygii.

Family CŒLACANTHIDÆ.

1. **Diplurus longicaudatus* Newberry.

Actinopterygii.

Family CATOPTERIDÆ.

2. **Catopterus gracilis* J. H. Redfield.
3. **Catopterus redfieldi* Egerton.
4. **Dictyopyge macrura* (W. C. Redfield).

Family SEMIONOTIDÆ.

5. **Acentrophorus chicopensis* Newberry.
6. **Semionotus agassizii* (W. C. Redfield).
7. *Semionotus brauni* (Newberry).
8. *Semionotus elegans* (Newberry).
9. **Semionotus fultus* (Agassiz).
10. *Semionotus gigas* (Newberry).
11. *Semionotus lineatus* (Newberry).
12. **Semionotus micropterus* (Newberry).
13. **Semionotus ovatus* (W. C. Redfield).

14. *Semionotus robustus* (Newberry).
15. **Semionotus tenuiceps* (Agassiz).

Family EUGNATHIDÆ.

16. **Ptycholepis marshi* Newberry.

On comparing the foregoing lists, it appears that both faunas — the Lombardy and the eastern North American — are made up exclusively of ganoids; and of these a single Crossopterygian family is represented in each case, while the remainder belong to the Actinopterygian order. Sharks and rays, Chimæroids and Lung-fishes, are conspicuously absent from both regions. Of the two families common to both provinces, of which *Semionotus* and *Catopterus* are representatives, the former is in each case the most important in point of numerical abundance, and is represented by the largest number of species. *Dictyopyge* is not common to both regions, nor conclusive as to age, since it ranges from the Bunter to the Upper Keuper in the Anglo-German Trias, and is known also from the Karoo formation of British South Africa and the Upper Trias of New South Wales. Two of the remaining genera of the American Trias are exceedingly rare in the Occidental region, each being represented by a solitary species. These are *Acentrophorus* and *Ptycholepis*. Of the former it is to be observed that it is apparently capable, despite its imperfect preservation, of being included in the same family as *Semionotus;* and as for the latter, of which only a few examples have been found at a single locality, near Durham, Connecticut, it is significant to note its occurrence at a slightly higher horizon in the Alpine Keuper (Besano and Raibl), where it is likewise accompanied by members of the Semionotidæ.

From the facts that have just been set forth one may infer that the so-called "Newark" fish fauna of this country is of more or less composite character, in that its chief constituents, or their analogues at least, are distributed between the middle (Ladinian) and upper (Keuper) divisions of the Alpine Trias. That a general correspondence exists between the Atlantic border fish fauna and that of the Middle Trias of Lombardy is now sufficiently evident; such relations as can be predicated between the former and various Keuper fish faunas of the Mediterranean

region (southern and eastern Alps) will be apparent to students from the following tabulation.

FISH FAUNA OF THE RAIBL BEDS (BASE OF THE ALPINE KEUPER) IN ITALY AND AUSTRIA.

BESANO, LOMBARDY.	RAIBL, CARINTHIA.
Elasmobranchii.	
1. *Acrodus bicarinatus* Bassani.	
2. *Hybodus* sp. ind.	**Crossopterygii.**
3. *Nemacanthus tuberculatus* Bassani.	Family CŒLACANTHIDÆ.
4. *Leiacanthus pinii* Bassani.	1. *Graphiurus callopterus* Kner.
5. *Leptacanthus cornaliæ* Bellotti.	
Actinopterygii.	**Actinopterygii.**
Family BELONORHYNCHIDÆ.	Family BELONORHYNCHIDÆ.
6. *Belonorhynchus curionii* (Bellotti).	2. *Belonorhynchus striolatus* Bronn.
7. *Belonorhynchus intermedius* Bassani.	3. *Belonorhynchus* sp. (= *Teleosaurus tenuistriatus* Kner *errore*).
8. *Belonorhynchus stoppanii* Bassani.	
9. *Belonorhynchus striolatus* Bronn.	
Family SEMIONOTIDÆ.	Family SEMIONOTIDÆ.
10. *Colobodus bassani* De-Alessandri.	4. *Colobodus ornatus* Agassiz.
11. *Colobodus varius* Giebel (= *Gyrolepis* sp. Bellotti MS. *fide* Bassani).	
12. *Colobodus triasicus* (Bassani) (= *Lepidotus triasicus* Bassani).	
13. *Allolepidotus* sp. ind.	
14. *Dapedius* sp. ind. (= *Tetragonolepis* sp. Bassani).	
Family MACROSEMIIDÆ.	Family MACROSEMIIDÆ.
15. *Ophiopsis bellotti* (Bassani) (= *Nothosomus bellotti* Bassani).	5. *Orthurus sturii* Kner.

Besano, Lombardy.	Raibl, Carinthia.
Family Eugnathidæ.	Family Eugnathidæ.
16. *Ptycholepis barboi* Bassani.	6. *Ptycholepis avus* Kner.
17. *Heterolepidotus gibbus* (Bassani) (= *Semionotus gibbus* Bassani *non* Seebach).	7. *Ptycholepis tenuisquamata* Kner.
Family Pholidophoridæ.	Family Pholidophoridæ.
18. *Pholidophorus barazzetti* Bassani.	8. *Pholidophorus bronni* Kner.
19. *Pholidophorus besanensis* Bassani.	9. *Pholidopleurus typus* Bronn.
20. *Pholidophorus cf. bronni* Kner.	10. *Peltopleurus splendens* Kner.
21. *Pholidophorus meridensis* De-Alessandri.	11. *Peltopleurus* (?) *gracilis* Kner.
22. *Pholidopleurus typus* Bronn.	12. *Thoracopterus apus* Kner.
23. *Peltopleurus splendens* Kner.	13. *Thoracopterus niederristi* Bronn.
	14. *Prohalecites microlepidotus* (Kner).
Family Pachycormidæ.	15. *Megalopterus raiblianus* Kner.
24. *Urolepis* sp. ind.	

The above lists have been compiled chiefly from the writings of Kner[1] and Bassani,[2] and the more recent memoir of De-Allessandri (1910). These assemblages from the marine Keuper of southern Europe are instructive as showing the continued importance of the Semionotidæ, and their accompaniment by *Ptycholepis* and a single Crossopterygian genus different from either our own *Diplurus* or the unique *Heptanema* of Perledo.

[1] Several articles on the fossil fishes from Raibl, contained in vols. 53, 55, and 56 of the *Sitzungsber. Akad. Wiss., Wien.*, 1866-67.

[2] Bassani, F., Sui fossili e sull'età degli schisti bituminosi triasici in Lombardia. *Atti della Soc. Ital. di Sci. Nat.*, 1886, xxix, pp. 15-72.

Compare also the lists given by Baron Achille de Zigno, in his "Pesci fossili di Lumezzane in Val Trompia (Lombardia)." *Mem. R. Accad. dei Lincei*, 1891, anno 287, p. 5. A comparative table of the Raibl and Lombardy section will be found at page 325 of Arthaber's work on the Alpine Trias, in Frech's "Lethæa Geognostica." For a history of previous attempts at a correlation of the Besano and Raibl faunas, see page 62 of Bassani's paper above cited.

Catopterus is indeed absent, but a possible offshoot from the ancient Palæoniscoids is found in the Pachycormid genus *Urolepis*.

Thus far we have been able to trace a certain similarity or at least a not remote correspondence, between our local "Newark" fish fauna and various assemblages belonging to the Upper Muschelkalk and Lower Keuper of the European marine Trias. Extending now the range of our comparison to a higher horizon, the fact cannot be gainsaid that there is in these later Mediterranean fish faunas appreciably less resemblance to that of the Atlantic border. The next higher horizon with which comparison of this nature is possible is the Hauptdolomit of various parts of Austria and Italy, a formation which is homotaxial with the Anglo-German Upper Keuper (Steinmergelkeuper), and is immediately succeeded by the Rhaetic. Everywhere in this later horizon, however, we meet with a more advanced expression of piscine evolution, and the character of the fauna acquires a decided Liassic aspect. We have, in fact, passed the limital division of the Keuper with which our "Newark" fish fauna can be most satisfactorily correlated, the ulterior bound being the Raibl beds of the Lower Keuper. This tends, therefore, to confirm the conclusion already put forward that the Triassic fish fauna of eastern North America is of more or less manifold nature, and corresponds in a general way to the interval between the uppermost Muschelkalk and the basal division of the Keuper in the Mediterranean region.

A tabulation of the Upper Keuper fish fauna of southern Europe is offered at this point by way of illustrating its more advanced grade in the scale of development. This has been compiled from both the older and more recent literature, including the writings of Kner,[1] Deecke,[2] de Zigno,[3] Bassani,[4]

[1] Kner, R., Die fossilen Fische der Asphaltschiefer von Seefeld in Tirol. *Sitzungsber. Akad. Wiss. Wien.*, 1866, liv, pp. 303-334. Nachtrag. *Ibid.*, 1867, lvi, pt. 1, pp. 898-909.

[2] Deecke, W., Ueber Fische aus verschiedenen Horizonten der Trias. *Palaeontogr.* 1889, xxxv, pp. 97-138.

[3] De Zigno, A., Pesci fossili di Lumezzane in Val Trompia. *Mem. R. Accad. dei Lincei,* 1891, anno 287, pp. 1-10.

[4] Bassani, F., Sui fossili e sull' età degli schisti bituminosi di Monte Pettine presso Giffoni Valle Piana in Provincia Salerno (Dolomia principale). *Mem. della Soc. Ital. delle Sci.* (detta dei XL), 1893, ser. 3, ix, no. 3. *Idem,* La Ittiofauna della Dolomia principale di Giffoni (prov. di Salerno). *Palaeontogr. Italica,* 1895, i, pp. 169-210.— *Idem,* Elenco dei Pesci fossili degli schisti bituminosi triasici di Giffoni, nel Salernitano. *Rend. della R. Accad. delle Sci. di Napoli,* 16 Dec. 1899.

Gorjanovic-Kramberger,[1] De-Alessandri,[2] and others. The numerals indicate the number of species represented at the respective localities, which are as follows: Lumezzane, in Val Trompia, Lombardy; Seefeld, near Innsbruck, Tirol; Hallein, in Salzburg, Austria; and Giffoni, in the Province of Salerno, southern Italy.

COMPARATIVE TABLE OF HAUPTDOLOMIT FISH FAUNAS.

Genera	Giffoni	Hallein	Seefeld	Lumezzane
Crossopterygii				
Fam. CŒLACANTHIDÆ				
1. *Undina*	1	..	..	..
Actinopterygii				
Fam. BELONORHYNCHIDÆ				
2. *Belonorhynchus*	1	..	1	..
Fam. SEMIONOTIDÆ				
3. *Semionotus*	..	1	..	..
4. *Colobodus*	2	2	2	2
5. *Heterolepidotus*	..	2	1	..
6. *Dapedius*	1	1	1	..
7. *Spaniolepis*	..	1	..	..
Fam. MACROSEMIIDÆ				
8. *Ophiopsis*	..	1	..	..
9. *Orthurus*	..	..	..	1
Fam. PYCNODONTIDÆ				
10. *Mesodon*	..	1	..	..
Fam. EUGNATHIDÆ				
11. *Eugnathus*	1	..	1	..
Fam. PHOLIDOPHORIDÆ				
12. *Pholidophorus*	3	2	4	4
13. *Peltopleurus*	1	.	1	..
14. *Thoracopterus*	1	..	..	..
Total number of species	11	11	11	7

A final word may now be said concerning the relations between the Atlantic border or "Newark" fish fauna and the meagre indications of Triassic fish life that have been obtained

[1] Gorjanovič-Kramberger, K., Die obertriadische Fischfauna von Hallein in Salzburg. *Beitr. Paläont. Geol.* 1905, xviii, pp. 193-224.

[2] De-Alessandri, G., Studii sui Pesci Triasici della Lombardia. *Mem. della Soc. Ital. di Scienze Naturali e Museo Civico di Storia Nat. di Milano,* 1910, vii, pp. 1-148.

from western North America. Owing to the well known intimate connection between the Upper Trias of California and that of southern Europe — the region which Neumayr years ago called the "central Mediterranean," and for which the name "Thetys" was proposed by Suess in 1894 — we might expect on purely *a priori* grounds to find a certain resemblance in the character of the vertebrate faunas of the two regions.[1]

The scant evidence thus far obtained, however, at least as regards the fishes, fails to justify any such expectation. From the Lower Trias of Idaho have been described a single detached dermal spine, apparently belonging to *Asteracanthus*,[2] and a few fragmentary remains of Crossopterygii, which are possibly late survivals of Paleozoic families (Rhizodontidæ and Osteolepidæ).[3] Elasmobranchs and effete Crossopterygii persist even as late as the Upper Trias of Shasta county, California, where remains of *Hybodus, Acrodus, Holoptychius* and *Xenestes* have been brought to light, whose number, however, all told, makes an inconspicuous showing.[4]

Yet another sprinkling of ichthyic indications is known from the Red Beds of supposed Triassic age (Shinarump group) in southwestern Colorado and in the Kanab Canyon region of Utah and Arizona. Little has been published on the fossil vertebrate remains from this section,[5] but, so far as the fishes are concerned, it is clear that they display no intimate relations with those of the Atlantic border Trias. On the contrary, the general aspect

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[1] In regard to the invertebrate faunas, Dr. James Perrin Smith has the following: "The most interesting fact brought out by a comparison of the Upper Trias of California with that of India and the Alpine Mediterranean region is its near relationship with the latter, most genera and many species being common to the two regions. . . . This relationship of the Californian to the European faunas persists until after the middle of the Jurassic formation, when the Boreal fauna comes in."— *Journ. Geol.*, 1898, vi, p. 786.

[2] This is described under the name of *Cosmacanthus* by H. M. Evans, in *Bull. Dept. Geol. Univ. of Calif.*, 1904, iii, p. 397.

[3] Goddard, M., Fish Remains from the Marine Lower Trias of Aspen Ridge, Idaho. *Bull. Dept. Geol. Univ. of Calif.*, 1907, v, p. 145.

[4] Wemple, E. M., New Cestraciont teeth from the West American Triassic. *Bull. Geol. Dept. Univ. of Calif.*, 1906, v, no. 4, p. 73.— Jordan, D. S., The Fossil Fishes of California. *Ibid.*, 1907, v, no. 7, pp. 95-144.

[5] The chief literary references are collected by Dr. Whitman Cross in his article on "The Triassic Portion of the Shinarump Group, Powell," to be found in the *Journal of Geology*, 1908, xvi, pp. 97-123. See also the joint paper by the same author and E. Howe, entitled "Red Beds of Southwestern Colorado and their Correlation." *Bull. Geol. Soc. Am.*, 1905, xvi, pp. 447-486.

of the Shinarump material suggests the foreshadowing of Jurassic conditions, and on that account the fauna announces itself as proemial, to employ Dr. Clarke's expressive term. The condition of the remains from the Kanab Canyon region is extremely fragmentary, and among them only the genus *Pholidophorus* and certain Lepidotidæ appear to be tolerably well indicated.

III. GEOGRAPHY OF THE TRIAS.

"It is the soul that sees: the outward eyes
Present the object, but the mind descries."
—*Longfellow.*

In this section it is not at all within our purpose to enter into an elaborate account of the physical conditions prevailing during the initial period of the Mesozoic, the theme being in itself an intricate one, and moreover, that phase of it which applies to our local section having been already sufficiently discussed. Such being the case, it will be sufficient merely to direct attention to a contribution pertinent to this topic, and one which contains perhaps the most comprehensive review that has been written on the faunal geography of the Upper Trias. We refer to the chapter on "The Seas of the Trias Era," by the late Professor E. Mojsisovics, Edler von Mojsvar, in his memoir on Triassic Cephalopods from the Himalayas,[1] wherein is collected practically all that is known of the distribution and relations of the invertebrate faunas of this era.

From this memoir, owing to its relevancy to the present discussion, we have ventured to extract a paragraph or two in regard to the principal regions of the "Central Mediterranean Sea" of Neumayr, or "Thetys" of Suess, from which Triassic faunas are known. So different from one another in character are these faunas that they are manifestly to be regarded as representing ancient geographic regions. These provinces are, in the language of their chief exponent and interpreter, as follows:

"1. Die Mediterranprovinz,
2. die germanische Flachsee, und
3. die indische Provinz."

Concerning the limits of these provinces the author remarks: "Die germanische Flachsee bildet eine Dependenz der Mediterranprovinz, und kann als ein grosses Aestuarium aufgefasst werden, welches dem ausgedehnten, heute im atlantischen Océan

[1] *Denkschr. k. k. Akad. Wiss.*, 1896, lxiii, p. 687.

versunkenen Continente vorgelagert war. Diese triadische 'Atlantis' existirte wahrscheinlich bereits am Schluss des paläozoischen Zeitalters.[1] Sie reichte im Westen vermuthlich bis zum heutigen Nordamerica,[2] welches bekanntlich auf seiner Osthälfte ausgedehnte triadische Binnensedimente vom Charakter des germanischen Buntsandsteines und Keupers besitzt, während pelagische Sedimente der Trias blos auf dem pacifischen Abhange dieses Continentes anzutreffen sind."

Expressed in English, the meaning of the above paragraph would be that the second of these geographical provinces forms a restricted area of the first, and may be regarded as having formerly been a large estuary of an extensive land area now submerged beneath the Atlantic Ocean. This hypothetical Triassic continent, the so-called "Atlantis," probably became elevated above sea level at least as early as the close of the Paleozoic. It presumably extended westward to the present continent of North America, for along the eastern border of the latter are found non-marine Triassic deposits corresponding to the central European Buntsandstein and Keuper, while marine Triassic rocks occur only along the Pacific slope. [It is proper to point out that the theory of a submerged "Atlantis" is by no means universally held among modern geologists, but on the contrary many of the foremost authorities are firm believers in the permanence of continental land masses.]

To pursue this topic of paleogeography a step further, it is of interest to recall that the eastern and western boundaries of the Triassic Thetys are thus delineated by Professor James P. Smith, in his article on the "Classification of Marine Trias" (*Journ. of Geol.*, 1896, iv, p. 387):

"Along the western borders of Thetys were deposited the Triassic sediments of the Alps, Spain, southern Italy, the

[1] Suess, Antlitz der Erde., ii, p. 317.

[2] Einen sicheren Anhaltspunkt für die Annahme eines solchen Continents bieten auch die Pflanzenreste dar, welche in den Kohlenfeldern des östlichen Virginiens gefunden und von Stur mit den Pflanzen des Lunzer Sandsteins (julische Stufe) identificirt wurden. Vergl. *Stur*, "Die Lunzer-(Lettenkohlen-) Flora in den 'older Mesozoic beds of the Coalfields of eastern Virginia.'" *Verh. Geol. Reichsanstalt*, 1888, p. 203.

Besides the paper of Stur's just referred to, one may consult the following by F. Zeller, which contains a comparison with the Alpine Trias: Beiträge zur Kenntniss der Lettenkohle und des Keupers in Schwaben. *Neues Jahrb. f. Mineral. u. s. w.*, Beilage-Bd. xxv, 1908, pp. 1-134. His correlation of the fish-bearing beds of the Alpine Trias is essentially the same as that adopted in the present Report.

Balearic Islands, Sicily, Hungary, and the Balkan Peninsula. This region was named by Mojsisovics the Mediterranean Trias province. Most of the faunas of the Trias, from near the base to the top, are represented in this region.

To the east the Thetys spread out to the waters of the Indian region, in which the sediments of the Himalayas and the Salt Range were accumulated. The Indian waters joined on the north, east and south with the great Arctic-Pacific Trias ocean, or Arctis of Mojsisovics, along the borders of which were deposited the sediments of northern and eastern Siberia, Spitzbergen, Japan, Rotti, New Zealand, New Caledonia, Peru and western North America. But in this ocean region there were many provinces as yet unknown, or only vaguely defined."

IV. CONCERNING EARLIER INVESTIGATION OF NORTH AMERICAN TRIASSIC FISHES.

"In den Wissenschaften ist es höchst verdienstlich, das unzulängliche Wahre, was die Alten schon besessen, aufzusuchen und weiter zu führen."
— *Goethe.*

American vertebrate paleontology may be said to have begun with President Thomas Jefferson's description of fossil elephant remains from Virginia[1] in 1787, and the bones of *Megalonyx,* afterwards named *M. jeffersoni,* a dozen years later.[2] One has to turn back a little more than a century earlier, however, for the first published figure of an American fossil, this being *Ecphora quadricostata* from the Maryland Miocene.[3] The earliest records of all relating to the discovery of fossil vertebrate remains in the western hemisphere date from the time of Hernandez, court physician to Philip II, and other Spanish explorers of the seventeenth century.[4]

We cannot be sure when fossil fishes first began to attract attention in this country, but the earliest notices regarding them in any scientific publication fall within the second decade of the last century, and relate to remains discovered in the Connecticut Valley region. Several titles are comprised in these early notices, and among their authors occur such names as S. L. Mitchell, B. Silliman the elder, Edward Hitchcock, A. Brongniart, W. W. Mather, James E. Dekay, and others. *Per contra,*

[1] Notes on the State of Virginia. London, 1787.

[2] A Memoir on the Discovery of certain bones of a Quadruped of the clawed kind in the western parts of Virginia. *Trans. Amer. Phil. Soc.,* 1799, iv, pp. 246-260. Dr. O. P. Hay is authority for the statement that this work is said by C. G. Giebel to have been issued in 1797.

[3] Lister, M., Historia sive Synopsis Methodicæ Conchyliorum. London, 1685. Pl. 1059, fig. 2.

[4] References to old Spanish works in which these remains are attributed to a race of human giants are given in the second volumes respectively of Cuvier's "Ossemens Fossiles" and Humboldt's "Cosmos." The vulgar interpretation, which is apparently common to all primitive society, ancient and modern, finds an apt illustration in the Gigantomachia of classical antiquity. Consult the suggestive article by Dr. Th. Skouphos, in *Comptes rendus Cong. Inter. d'Arch.,* Athens, 1905, pp. 231-236. Also one by E. von Lasaulx on the Geology of the Greeks and the Romans, in *Abhandl. bayer. Akad. Wissensch.,* 1852, vi, pp. 517-566.

the occurrence of similar remains in the more southerly region does not seem to have become generally known until toward the middle of the nineteenth century. Those from the Virginia Coal fields were studied successively by the Redfields, father and son, Sir Charles Lyell, Sir Philip Grey Egerton, and Louis Agassiz; and a brief mention of fragmentary remains from North Carolina, accompanied by a few figures, was contributed by Ebenezer Emmons during the late fifties.

It is, however, to William C. and John H. Redfield, who wrote between 1837 and 1857, that we are indebted for the first really satisfactory account of the Triassic fish fauna of this country, these two having described nearly all the important species. Their results are embodied in ten publications, eight by the elder, and two by the younger author. These same pioneers also brought together an important collection, of which a good part is still preserved in the Peabody Museum at Yale University, and the rest is unfortunately destroyed or dissipated.

By far the most signal contribution to our knowledge of American Triassic fishes is that contained in Professor J. S. Newberry's "Monograph on the Fossil Fishes and Fossil Plants of New Jersey and the Connecticut Valley."[1] Several new species of *Semionotus* (described, however, under the title *Ischypterus*), *Ptycholepis* and *Diplurus* were established by him upon the evidence of tolerably satisfactory material, and one doubtful form was referred with some reservation to *Acentrophorus,* a genus that is otherwise limited, so far as known, to the Upper Permian. This elaborate work of Professor Newberry still remains our chief repository of information in regard to the particular subject before our consideration.

Since Newberry's time comparatively little has been added to our knowledge of the Newark fish fauna, except in the way of rectifying some minor details. An important memoir on the genus *Semionotus,* by Dr. E. Schellwien,[2] appeared in 1901, in which a few new anatomical points, accompanied by illustrations, are worked out for two previously known American species. A number of additional structural characters were made known in 1903 by Dr. George F. Eaton, of Yale University, in the case

[1] *Monogr. U. S. Geol. Surv.,* xiv. Washington, 1888.

[2] Schellwien, E., Ueber Semionotus Ag. *Schriften der Phys.-Oekonom. Gesellsch. zu Königsberg i. Pr.,* 1901, pp. 1-34, pl. i-iii.

of four or five American species of *Semionotus*.[1] The diagnosis of this genus was further emended by Professor Gorjanovic-Kramberger, still more recently, in the course of his description of the Upper Triassic fish fauna of Hallein, Salzburg.[2] In this memoir the author set forth evidence intending to show that the family position of *Heterolepidotus* is with the Semionotidæ rather than with the Eugnathidæ, and that *Allolepidotus* of Deecke is identical with *Semionotus* proper.

During the same year, 1905, some revised descriptions of the Triassic fishes of New Jersey were published by the present writer, with incidental mention of Connecticut Valley forms.[3] Reference was made in this paper to the totally different character of the Kanab Valley fish fauna (Triassic portion of the Shinarump group, Powell) as compared with that of the Atlantic border region, and it was pointed out that the former displayed a marked Liassic aspect. That the beds which carry this fauna are in reality anterior to the Lias, and probably belong to the late Trias, has been recently argued by Dr. Whitman Cross in the *Journal of Geology* for 1908. The few contributions that have appeared in regard to the Triassic fishes of the Cordilleran region have already been referred to in the preceding section.

In regard to restorations of the leading genera *Semionotus* and *Dictyopyge*, figures of these were published as early as 1864 by J. Struver, which are fairly accurate in respect to form of body and fin-structures, but leave much to be desired in the representation of cranial and facial bones. These figures are reproduced by Frech in his Introduction to the Mesozoic (Part II. of the "Lethæa Geognostica," Stuttgart, 1903), and two other illustrations of American Triassic fishes are copied in the same work from Newberry's Monograph (Texttafel vi, vii). No satisfactory restoration of *Catopterus* has yet appeared, but some figures of the head portion, prepared from original drawings by the late Professor Newberry, are now published for the first time in the present Report in the section devoted to that genus. (Figs. 5, 6, p. 54.)

[1] Eaton, G. F., Notes on the Collection of Triassic Fishes at Yale. *Amer. Journ. Sci.*, 1903, ser. 4, xv, pp. 259-268, pl. v, vi.

[2] Gorjanovic-Kramberger, K., Die obertriadische Fischfauna von Hallein in Salzburg. *Beitr. zur Paläont. und Geol.*, 1905, xviii, pp. 193-224, pl. xvii-xxi.

[3] Geol. Surv. N. J., Ann. Rept. for 1904 (1905), pp. 67-102.

V. SYSTEMATIC DESCRIPTIONS OF UPPER TRIASSIC FISHES.

"Die Natur ist das einzige Buch, das auf allen Blättern gewissen Inhalt bietet."— *Goethe.*

Order **CROSSOPTERYGII.**

Family CŒLACANTHIDÆ.

"Body deeply and irregularly fusiform, with cycloidal, deeply overlapping scales, more or less ornamented with ganoine. Branchiostegal apparatus consisting of an operculum on each side and a single pair of large jugular plates. Paired fins obtusely lobate. Two dorsal fins and a single anal; the anterior dorsal without baseosts, the posterior dorsal and the anal with baseosts, obtusely lobate. Axial skeleton extending to the extremity of the caudal fin, usually projecting and terminated by a small supplementary caudal fin. Air-bladder ossified."

As remarked by Smith Woodward, from whose Catalogue the foregoing definition has been taken, the members of this family have perhaps the most remarkable geological range of all known extinct fishes, persisting as they do practically unchanged from the Upper Devonian to the Upper Chalk. "The group is specialized," says this author, "in the large symmetrical caudal fin, which exhibits a series of supports directly apposed to the neural and hæmal arches, equalling in number both these and the overlapping dermal rays. It is also specialized in (i.) the fusion of the bones of the pterygo-quadrate arcade, (ii.) the reduction of the infradentaries to one, (iii.) the reduction of the opercular apparatus to the operculum on each side and a pair of gular plates, (iv.) the loss of the baseosts in the anterior dorsal fin, and (v.) the ossification of the air-bladder."

This family, first proposed by Louis Agassiz in the second volume of his "Poissons Fossiles" (1844, p. 168), and afterwards greatly restricted by Huxley in two important memoirs of the British Geological Survey (Decades X and XII, 1861 and 1866), is at present understood as comprising not more than six

well recognized genera, among which the most satisfactorily known are *Cœlacanthus* proper, *Macropoma* and *Undina*. The typical genus enjoys the truly remarkable range from the Upper Devonian to the close of the Paleozoic, and, if the evidence of one or two doubtful forms be accepted, possibly even higher; the remaining genera extend throughout the Mesozoic, and exhibit such constancy of structural characters that the family has been frequently cited as one of the most distinct and well defined in the animal kingdom. Huxley, for instance, drew attention to its singular compactness and homogeneity in the following paragraph:[1]

"The Cœlacanthini, as thus understood, are no less distinctly separated from other fishes than they are closely united to one another. In the form and arrangement of their fins; the structure of the tail and that of the cranium; the form and number of the jugular plates; the dentition; the dorsal interspinous bones; the pelvic bones; the ossified air-bladder; the Cœlacanthini differ widely from either the Saurodipterini, the Glyptodipterini, or the Ctenodipterini; but, on the other hand, they agree with these families and differ from almost all other fishes, in the same respects as those in which the several families just mentioned have been shown to agree with one another, viz., the number of the dorsal fins, the location of the paired fins, the absence of branchiostegal rays and their replacement by jugular bones."

Finally, concerning the extraordinary conservatism and persistence manifested by the group of Cœlacanth fishes ever since its introduction, the illustrious English biologist whom we have quoted expresses himself as follows:[2]

"Bearing in mind the range of the Cœlacanths from the Carboniferous [since ascertained to extend from the Devonian] to the Chalk formation inclusive, the uniformity of organization of the group appears to be something wonderful. I have no evidence as to the structure of the base and side walls of the skull in *Cœlacanthus,* but the data collected in the present Decade

[1] Huxley, T. H., Preliminary Essay upon the Systematic Arrangement of the Fishes of the Devonian Epoch, prefixed to the Tenth Decade of the Figures and Descriptions illustrating British Organic Remains (1861, p. 20).

[2] Illustrations of the Structure of the Crossopterygian Ganoids. *Memoirs of the Geological Survey of the United Kingdom,* Decade xii, 1866. Reprinted in the supplementary volume of the Scientific Memoirs of Thomas Henry Huxley, 1903, p. 65.

shows that, in every other particular save the ornamentation of the fin-rays and scales, the organization of the Cœlacanths has remained stationary from their first recorded appearance to their exit. They are remarkable examples of what I have elsewhere termed "persistent types;" and, like the Labyrinthodonts, assist in bridging over the gap between the Palæozoic and the Mesozoic faunæ."

The earliest known American representative of this family is a typical Cœlacanth, described as *Cœlacanthus welleri*,[1] from the Lower Kinderhook (base of the Mississippian series) of Iowa. Three other species are known from the Coal Measures of Ohio and Illinois, but none from later horizons until we meet with the very remarkable and in some respects degenerate (*e. g.*, as regards loss of certain of its head bones and most of its tail) *Diplurus* in the "Newark" rocks of the Atlantic border region. So far as known, this genus comprises but a single large species, *D. longicaudatus,* which is common to both the Connecticut Valley and New Jersey areas. A vicarious form, to use a German expression, or perhaps what President Jordan would call a "geminate species" or genus,[2] is represented in the Perledo limestone of Lombardy by *Heptanema paradoxum* Bellotti.

Genus **Diplurus** Newberry.

Supplementary caudal fin prominent, with much elongated pedicle; fin-rays robust, closely articulated in the distal half; preaxial rays of the first dorsal and caudal fins with spinous tubercles. Scales and head bones irregularly striated, and some of the latter finely granulated.

Diplurus longicaudatus Newberry.

1878. *Diplurus longicaudatus* J. S. Newberry, Ann. N. Y. Acad. Sci., i, p. 127.

1888. *Diplurus longicaudatus* J. S. Newberry, Monogr. U. S. Geol. Surv., xiv, p. 74, pl. 20.

1891. *Diplurus longicaudatus* A. S. Woodward, Cat. Foss. Fishes Brit. Mus., pt. 2, p. 409.

1905. *Diplurus longicaudatus* C. R. Eastman, N. J. Geol. Surv. Rept. for 1904, p. 101.

[1] *Journ. Geol.*, 1908, xvi, p. 357.

[2] Jordan, D. S., The law of geminate species. *Am. Nat.*, 1908, xlii, p. 73.

The type and only known species, attaining a total length of about 70 cm. to the tip of the supplementary caudal fin, and maximum depth of trunk about 20 cm. Anterior dorsal fin strong, supported by a single large laminar axonost; the lobate posterior dorsal nearly opposite the anal, and corresponding to it in form and size. Caudal fin much elongated, and separated from the supplementary caudal by a distinct interval. Paired fins obtusely lobate. Scales large, cycloidal, and deeply overlapping; the exposed portion marked with fine longitudinal rugæ; teeth unknown.

This large Crossopterygian is of extremely rare occurrence, being known by a scant half-dozen individuals, of which two, including the type, were obtained from near Boonton, New Jersey, and the others, very imperfect, from Durham, Connecticut. Most of the remains are now preserved in the American Museum of Natural History in New York, but there is one distorted example of the lower jaw in the Museum of Wesleyan University at Middletown (Cat. No. 846), which was collected by Mr. S. W. Loper from the anterior shales. Unfortunately this specimen shows no satisfactory indication of teeth, but appearances are at least suggestive that these were slender and conical. The external surface of the bone is finely granulated.

Order **ACTINOPTERYGII.**

Paired fins non-lobate, having an extremely abbreviated endoskeletal portion, and the dermal rays prominent. Caudal fin abbreviate-diphycercal, heterocercal, or homocercal. A single paired series of transversely elongated rays, with or without an anterior azygous element, developed in the branchiostegal membrane between the mandibular rami.

Suborder **CHONDROSTEI.** Sturgeons.

In these fishes, the oldest and most primitive of the Actinopterygii, the notochord is more or less persistent, the supports of the dorsal and anal fins are less numerous than the dermal rays apposed to them, the paired fins more abbreviate than in the Crossopterygian order, and the tail is completely heterocercal. Primitive sturgeons differ also from the fringe-finned

ganoids in the development of a paired series of transversely elongated branchiostegal rays to replace the pair of jugular plates between the mandibular rami; infraclavicular plates, however, are retained in both groups. Nearly all the older forms have a well developed rhombic and ganoid squamation. So far as known, the chondrocranium is but little ossified, and the cranial bones are mainly dermal.

The evolutionary history of the sturgeon tribe is thus summarized by Professor Bridge in the Cambridge Natural History volume on Fishes (1904, p. 485):

"The Chondrostei are first represented in the Lower Devonian by the solitary Palæoniscid genus *Cheirolepis,* a contemporary of the earliest Crossopterygii. They occur throughout the Mesozoic period, except in the Cretaceous, and also in the Eocene, and, while steadily diminishing in number and variety, they gradually approximate to their degenerate and in some respects highly specialized descendants, the sturgeons and paddlefishes of the existing fish fauna. Of the seven families included in the group, the Palæoniscidæ are the oldest and most generalized. The Platysomatidæ are a specialized offshoot from the Palæoniscidæ, and, if they are rightly to be considered as Chondrostei, perhaps the same may be said of the problematic Belonorhynchidæ. On the other hand, there are certain features which indicate an approach to Fishes of an altogether more modern type. Finally, the Chondrostei represent a stage in a career of degeneration, the climax of which is reached by the modern Polyodontidæ and Acipenseridæ."

Family CATOPTERIDÆ.

Trunk elongate or elongate-fusiform; tail abbreviate-heterocercal. Head bones well developed, ganoid; no median series of cranial roof-bones; teeth slender, conical; eye far forward, and snout prominent; mandibular suspensorium more or less obliquely directed backward and downward. A series of branchiostegal rays present. Dorsal fin single and not much extended. Scales rhombic, ganoid.

This short-lived family, in which are comprised not more than three closely related genera (*Catopterus, Perleidus,* and *Dictyopyge*), appears in the early Mesozoic just as the large and successful group of Palæoniscid fishes are entering upon their

decline. Derived in all probability from the ancient Palæoniscid stock, and still retaining certain of its characteristics, these genera represent an advance over primitive sturgeons in the direction of the next higher suborder (Protospondyli), yet without marking a definite transition to that group. The upper lobe of the tail has become shortened, although still heterocercal; and in *Dictyopyge* at least the supports of the anal fin are recorded as fewer in number than the apposed dermal rays. The family is accompanied in the Trias by other Chondrosteans which became eel-shaped (Belonorhynchidæ) and died out during that period. Still others, which gradually lost their scaly covering and head bones (*Chondrosteus*), continued to survive, and are represented by the sturgeons of the present day. The relations of this family are, therefore, with modern sturgeons rather than with the two surviving genera of Protospondyli, *Amia* and *Lepidosteus*.

Genus **Catopterus** Redfield.

(Syn. *Redfieldius* Hay.)

Trunk elegantly fusiform, head relatively small, tail hemiheterocercal. External bones more or less ornamented with ridges and tubercles of ganoine; no median series of cranial roof-bones. Fins of moderate size, consisting of robust rays, more or less enameled, and distally bifurcated; fulcra well developed, short and closely set. Dorsal and anal fins triangular, the origin of the former behind that of the latter; caudal fin forked. Scales large or of moderate size, nearly or quite smooth, and serrated along their postero-inferior margin; dorsal ridge-scales not much enlarged. Teeth numerous, small, acutely conical.

This genus appears to be restricted to the Atlantic Border Trias of North America, although a supposed Catopterid genus, named *Perleidus* by De-Alessandri, occurs in the Ladinian limestone of Lombardy, and the still more closely related genus *Dictyopyge* is of world-wide distribution.

It is to be noted that remains of *Catopterus* are on the whole less abundant than those of the accompanying genus *Semionotus*, both in the Connecticut Valley area and in New Jersey, and as a rule they are less well preserved. Nevertheless, the characters

presented by the former genus are so well marked and distinctive that there is seldom any difficulty in determining even the most fragmentary individuals. The most obvious peculiarity of the genus consists, as the name implies, in the remote position of the dorsal fin. In *Semionotus* the dorsal is always anterior to the anal fin, in *Catopterus* it is either opposite or posterior. The margins of all the fins are closely set with fine fulcra, in such wise that they present a delicately fringed appearance, and the fin-rays themselves are very numerous, finely articulated, and enameled. Other noticeable differences consist in the ornamented condition of the cranial bones, and serration of the hinder margin of the scales.

Whereas the genus *Semionotus* is represented in this country by half a dozen or more species, its associates *Catopterus* and *Dictyopyge* comprise a much smaller number, in fact not more than one or two each. After a critical study of differential characters we are forced to admit that only two species of *Catopterus* are capable of being clearly distinguished. These are *C. gracilis* Redfield and *C. redfieldi* Egerton, both founded on large and nearly complete fishes which differ from one another chiefly as regards proportions of body and scale characters. The so-called *C. parvulus* Redfield is probably to be regarded as the young of *C. gracilis,* and the species named by Newberry *C. minor* and *C. ornatus* are supposed to stand in a similar relation to *C. redfieldi.*

Catopterus gracilis J. H. Redfield.

(Plates IX-XI.)

1837. *Catopterus gracilis* J. H. Redfield, Ann. Lyceum Nat. Hist. N. Y., iv, p. 37, pl. 1.

1841. *Catopterus gracilis* W. C. Redfield, Am. Journ. Sci., [1] xli, p. 27.

1841. *Catopterus gracilis* E. Hitchcock, Final Rept. Geol. Mass., ii, pp. 440, 460.

1888. *Catopterus gracilis* J. S. Newberry, Monogr. U. S. Geol. Surv., xiv, p. 55, pl. 16, figs. 1-3.

1895. *Catopterus gracilis* A. S. Woodward, Cat. Foss. Fishes Brit. Mus., iii, p. 2.

1905. *Catopterus gracilis* C. R. Eastman, Ann. Rept. N. J. Geol. Surv. for 1904, p. 96.

The type species, attaining a total length of about 25 cm. Length of head with opercular apparatus about equal to maximum depth of trunk, and contained five times in the total length of the fish; depth of caudal pedicle somewhat less than one-half that of the abdominal region. Cranial bones finely granulated. Pelvic fins arising about midway between the pectorals and anal; dorsal and anal fins subequal in size, and almost completely opposed. Scales smooth, none deeper than broad, those of the flank in the abdominal region very finely serrated.

The fin-formula given for this species in the original description by J. H. Redfield is as follows:

D. 10-12; C. 30-40; A. 20-30; V. *circa* 8; P. 10-12.

In the additional notes on this form drawn up by the elder Redfield, it is stated that "the pectoral fins are of an elongated form, and are strengthened on the anterior margin by one or two large and partly flattened rays, to the front of which the fringe of fine raylets [fulcra] is attached. Owing to this peculiarity of structure, the smallest section of the pectoral fin will often serve to identify this species."

Although the form of body in this species is usually more slender than in *C. redfieldi,* it sometimes happens that distorted specimens, in which the anterior part of the trunk has become "shortened up" by mechanical deformation, simulate the deeper-bodied species in outline and general proportions. Conversely, also, the greater depth of body in *C. redfieldi* as compared with the genotype is often obscured by the familiar hazard of vertical compression, a circumstance which has frequently led to a confusion of the two species. Indeed, this very circumstance happens to be illustrated in the case of one of the original cotypes upon which the species was established by the younger Redfield; and so impressed was Newberry with the idea that the depth of body had become reduced by fortuitous agency that he actually proposed to cancel the specific name bestowed upon it by the original author, because, as he avers, for a fish which "in its normal condition has nearly the outline of the shad . . . the name of *Catopterus gracilis* is inappropriate and conveys a false impression."

Arbitrary and captious as Newberry's procedure appears to the modern systematist, such license was by no means uncommon, and, indeed, seems to have been not only tolerated but approved by the best paleontological authorities of his day. Nowadays, when nomenclatural codes are much more rigidly enforced, it would be contrary to all rule to abandon a valid specific name because of either a real or imaginary incongruity of meaning, and in cases where the name originally bestowed upon a species has become displaced for no more cogent reason than this, the tendency is to reinstate it. In the present instance it cannot be said that Newberry's proposal has become generally adopted, nor has it the sanction of long established usage; hence the only course open to us is to continue to recognize the original of Redfield's figure as one of the authentic cotypes of this species.

We are indebted to the generosity of Professor Schuchert for the privilege of reproducing a photograph of this well preserved exemplar (Plate IX), which is now the property of Yale University Museum. In this will be noted *inter alia* the Palæoniscid-shaped head, forwardly placed orbit, and tolerably distinct outlines of facial and cranial plates. The mandible, unfortunately, is missing, the striated opercular and tuberculated cheek plates are arranged after a different pattern from the corresponding parts in the Semionotidæ, and there is no clear indication of either a circumorbital ring or of branchiostegal rays.

Another nearly complete example of the same species is illustrated in Plate X. Like the first, it was obtained from near Durham, Connecticut, but from a somewhat higher level, the horizon being that known as the posterior shale.[1] Mr. S. W. Loper, who collected it, remarks that this is the only good specimen ever obtained from the beds in question, after many years of fruitless search. The specimen is remarkable for its well preserved squamation, and it also reveals the outline of the head much more satisfactorily than the Redfield cotype. The mandible is

[1] Most of the fossil fishes in the Connecticut valley have been found at two well-marked horizons. One stratum of black shale lies between the lower (anterior, Percival) and the thick middle or main lava sheet, another between the main and the upper (posterior, Percival) lava sheet. These two fossiliferous strata have been called accordingly the anterior and the posterior black shale. Davis and Loper, Two Belts of Fossiliferous Black Shale in the Triassic Formation of Connecticut. *Bull. Geol. Soc. Am.*, ii, pp. 415-430.

Palæoniscid-like, and still carries a few minute teeth. Remains of the same species are common to both the New England and New Jersey areas.

Catopterus redfieldi Egerton.

(Figs. 5, 6.)

1847. *Catopterus redfieldi* Sir P. G. Egerton, Quart. Journ. Geol. Soc., iii, p. 278.

1888. *Catopterus redfieldi* J. S. Newberry, Monogr. U. S. Geol. Surv., xiv, p. 53, pl. 15, figs. 1-3.

1895. *Catopterus redfieldi* A. S. Woodward, Cat. Foss. Fishes Brit. Museum, pt. 3, p. 3.

1903. *Catopterus redfieldi,* F. Frech, Lethæa geognostica, Part 2, Trias, p. 12, text-pl. 7, fig. 2.

1905. *Catopterus redfieldi* C. R. Eastman, Ann. Rept. Geol. Surv. N. J. for 1904, p. 98.

This species is described by its founder as "broader than the preceding [*C. gracilis*], and with scales not so long in proportion to their depth." The original definition has been supplemented by a number of differential characters observed by Newberry, and the extended description given by the American author has been condensed by Smith Woodward into the following paragraph:

"A comparatively robust species as large as the type. Length of head with opercular apparatus not more than two-thirds as great as the maximum depth of the trunk, and contained nearly six times in the total length of the fish; depth of caudal pedicle equaling about one-third that of the abdominal region. Cranial bones finely granulated. Pelvic fins arising midway between the pectorals and anal; dorsal and anal fins nearly equal in size, and the former arising opposite to the middle of the latter. Scales mostly smooth, but sometimes in part longitudinally striated, the striæ terminating in the coarse serrations of the posterior border which characterize the principal flank-scales; many of the flank-scales deeper than broad."

Neither in this nor in any other species of *Catopterus* has the structure of the head and shoulder-girdle been satisfactorily worked out, these parts being as a rule too imperfectly preserved

for study. Nevertheless, an attempt was made in this direction by J. S. Newberry, and it is perhaps worthy of note that the material upon which his restorations were based, together with certain unpublished figures and manuscript notes, are now the property of the American Museum of Natural History. For the privilege of studying both the original material and the records of Newberry's interpretation of them, the writer is indebted to the courtesy of his friend Dr. Bashford Dean, Curator of fossil fishes in the American Museum of Natural History in New York. With his permission, two of Newberry's original drawings are reproduced for the first time in Figs. 5 and 6, one representing the head portion viewed from above and to one side, the other from below.

With reference to the specimens serving as the basis of Newberry's restorations it may be remarked that the larger and more perfect (the one shown in Fig. 5, Cat. No. 2431) has the head portion preserved in the form of an impression, wherein certain sutural indications are plainly visible, others less clearly so. Three drawings of this specimen occur among Newberry's reliquiæ, all bearing explanatory legends in his handwriting. From a careful collation of these with the original it appears that our author was mistaken in his reading of several parts of the cranial osteology, more particularly as regards the cheek plates and opercular apparatus, and it is a question whether he has not sometimes mistaken grooves of the sensory canal system for suture lines.

But at the same time it must be admitted that precisely in these particulars, owing to lack of definiteness in the impression, there is room for considerable latitude of interpretation, and that after all a final judgment cannot be based upon this single specimen standing alone, without the aid of well authenticated points of control derived from comparison of a large quantity of material. No single specimen has yet come to light which reveals the lateral aspect of the head in thoroughly satisfactory manner, and any attempt to correct or improve upon Newberry's restoration must proceed from a mosaic built up of overlapping sections. Much effort has been expended by the present writer in this direction, and some progress has been made towards elaborating the complete cranial structure. Yet the work is

still incomplete, and, owing to deficiency of reliable material, the time has not yet come when a thoroughly satisfactory and authentic restoration can be given of the head. For the present, however, we may content ourselves with calling attention to the general Palæoniscid-like arrangement of the cranial plates, as far as the details have been worked out; and, in default of a tentative figure showing these parts, we may refer the reader to the different types portrayed in Fig. 7 on page 59, with special emphasis upon the approach made by *Catopterus* to the early and more primitive models.

A few words may be said in regard to the second of Newberry's drawings, which has this in common with the first, and indeed with all pioneer studies; that, however we may judge of its accuracy, it is at least an interesting historical document, and has a certain intrinsic value in so far as it acquaints us with a graphic presentation of the author's views at the stage he had then attained in his investigations. In Fig. 6 is represented Professor Newberry's idea of the structure of the under side of the head. A comparison of his drawing with the original specimen (Cat. No. 635 G) shows that the head is much distorted, the clavicle and infraclavicle being displaced far forwards, and thereby producing a very deceptive appearance. It may be stated positively that no median jugular plate is present, nor is any trace to be seen of the branchiostegal apparatus. The space included within the angle formed by the mandibular rami appears to have been covered in part by rhombic ganoid scales, in part by indurated skin ornamented with papillæ, but not occupied by distinct plates. Both of Newberry's originals were obtained from near Durham, Connecticut.

By way of summarizing the few definitely known facts that have been gleaned from a comparison of very numerous cranial fragments belonging to this species, the following points may be noted: The head is in general Palæoniscid-like. There is a pair of small parietals behind, in front of which are placed the narrow and elongate frontals, traversed longitudinally by sensory canals; and these are succeeded in turn by a median ethmoid of the form shown in Newberry's drawing (Fig. 5, *e*). This median system of plates is bounded on either side by three pairs of lateral plates which may be designated as the squamosal, postfrontal, and prefrontal. There is no circumorbital ring, and the

suborbitals are apparently few in number. The preoperculum is inconspicuous, and the posteriorly enlarged maxillary resembles or at least suggests in form that of Paleozoic Chon-

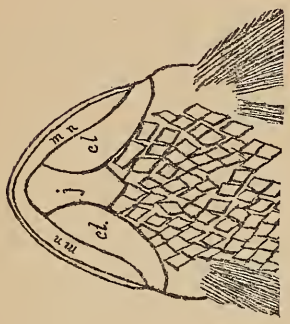

Fig. 6. *Catopterus redfieldi* Egerton. Trias; Durham, Connecticut. Reproduction of Newberry's original drawing (with manuscript legend), showing under side of the head, based upon a specimen preserved in the American Museum of Natural History, New York. × ½. *cl*, clavicle; *j*, jugular (so-called); *mn*, mandible.

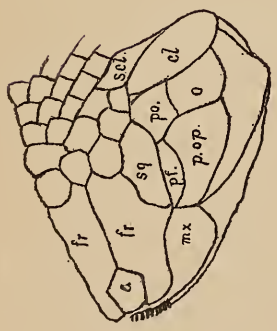

Fig. 5. *Catopterus redfieldi* Egerton. Trias; Durham, Connecticut. Reproduction of Newberry's original drawing (with manuscript legend), showing dorso-lateral aspect of the head, based upon a specimen preserved in the American Museum of Natural History, New York (Cat. No. 2431). × ½. *e*, ethmoid; *fr*, frontal; *mx*, maxillary; *sq*, squamosal; *pf*, postfrontal; *po*, (?); *p. op*, preoperculum; *o*, operculum; *cl*, clavicular scale; *scl*, supraclavicle.

drostei. It is beset with numerous fine, acutely conical teeth, and there is also a small dentigerous premaxilla which is often preserved in the dissociated state.

The distribution of *C. redfieldi* is identical with that of the type species, and, like the latter, it is more abundant at Durham than in any other locality.

Besides the two species we have just noticed, names have been proposed for several others whose status is very uncertain. Some are doubtless to be regarded as young individuals belonging to one or the other of the above characterized forms, and the types upon which others are founded defy adequate description. In the opinion of Smith Woodward, as remarked by him in Part III of his "Catalogue of Fossil Fishes," the so-called *Catopterus minor* Newberry is probably founded on immature and variously distorted examples of *C. redfieldi*. Further, the same author regards it as uncertain whether the type of *C. ornatus* Newberry should be associated with this species or some other. "The type," he says, "is a unique, much distorted, small specimen from Durham, which seems to have been chemically eroded in such a way as to display the concentric lines of growth in the scales" (*loc. cit.*, p. 3). It should be said with reference to this last statement that the concentric markings of the scales, which seem to be correlated with a subovate form of the latter, are to be seen only along a part of the flank, where the body has been much twisted upon itself. They fail to show in the impression which is visible of the opposite side of the body; and these two facts taken together tend to strengthen the belief that they are of accidental origin.

Genus **Dictyopyge** Egerton.

Distinguished from *Catopterus* only by the more anterior position of the dorsal fin, which never arises behind the origin of the anal.

Dictyopyge macrura W. C. Redfield.

1841. *Catopterus macrurus* W. C. Redfield, Am. Journ. Sci., [1] xli, p. 27.
1847. *Dictyopyge macrura* Sir P. G. Egerton, Quart. Journ. Geol. Soc., iii, p. 276, pl. 8; pl. 9, fig. 1.
1857. *Catopterus macrurus* W. C. Redfield, Proc. Amer. Assoc. Adv. Sci. 1856, pt. 2, p. 186.
1888. *Dictyopyge macrura* J. S. Newberry, Monogr. U. S. Geol. Surv., xiv, p. 64, pl. 18, figs. 1, 2.
1895. *Dictyopyge macrura* A. S. Woodward, Cat. Foss. Fishes Brit. Mus., pt. 3, p. 4, fig. 1.

1905. *Dictyopyge macrura* C. R. Eastman, Ann. Rept. Geol. Surv. N. J. for 1904, p. 99, pl. 13.[1]

A species attaining a total length of about 15cm. Length of head with opercular apparatus somewhat less than the maximum depth of the trunk, and contained nearly five times in the total length of the fish; depth of caudal pedicle less than one-half of that of the abdominal region. Cranial bones externally ornamented with fine granulations. Pelvic fins arising midway between the pectorals and anal fin; dorsal at least as high as long, arising slightly in advance of the anal, and nearly as large as the latter; anal with about 30 rays, and extending almost to the base of the caudal fin. Scales smooth, not serrated.

This, the type species of the genus, was originally described under the name of *Catopterus macrurus,* but was afterwards held by Sir Philip Grey Egerton to be excluded from association with the latter genus on account of the following differential characters: (1) "the dorsal fin is more strictly opposite to the anal than in *Catopterus redfieldi;*" and (2) "having a homocercal tail, it cannot be comprehended in it." It was pointed out by the elder Redfield, however, who denied that *Dictyopyge* was entitled to rank as an independent genus, that the type species was in reality no less heterocercal than other Catopteridæ, and "with the other common characters the slight difference in the position of the fins had in his judgment only a specific value." The close resemblance between the two genera, *Catopterus* and *Dictyopyge,* was also remarked by Newberry, who observes: "The only differences which I can specify between our commonest species of *Catopterus* and *Dictyopyge* are the broader operculum, the narrower scales of the belly, and the less deeply forked tail of the latter."

This species occurs typically in the Upper Trias of the Virginia Coal field, and its presence has not previously been reported elsewhere. There is, however, in the collection belonging to the Museum of Comparative Zoology at Cambridge a single specimen (Cat. No. 2531), labelled as having been derived "probably from Middletown, Connecticut," and erroneously referred in the above-cited publication to the type species of *Catopterus.* Regarded as a young individual of that species, it was figured under that name by the present writer in the Report

[1] The original of this plate is here incorrectly assigned to *Catopterus.*

of the State Geologist of New Jersey for 1904. A reconsideration of its characters, however, especially the remote position of the dorsal fin, and the appearance of the squamation and opercular plates, leaves little room to doubt that its affinities are with *Dictyopyge*. Nor does any good reason appear for doubting the trustworthiness of the record of the locality whence the specimen was derived. The micaceous grains in the matrix are a characteristic feature of the Connecticut Valley sandstone, and the general appearance of the rock is wholly dissimilar to the prevailing type of deposit occurring either in New Jersey or Virginia. For the present, therefore, the evidence of this specimen must be accepted as proving the presence of *Dictyopyge* in the Connecticut Valley area.

Suborder **PROTOSPONDYLI.**

In this suborder, as distinguished from Paleozoic and early Mesozoic Chondrosteans, the median fins become absolutely complete, in that each separate ray has its own individual support. At the same time the upper lobe of the tail is considerably shortened, so that the caudal fin forms a flexible fan-shaped expansion at the blunt end of the body. The members of this suborder chiefly characterize the Triassic and Jurassic periods, and exhibit endless variety; but their sole survivors at the present day are the long-bodied garpike (*Lepidosteus*) and bowfin (*Amia*) of American fresh waters.

Family SEMIONOTIDÆ.

Trunk more or less deeply fusiform, rarely cycloidal. Cranial and facial bones more or less robust, and opercular apparatus complete. Gape of mouth small, teeth styliform or modified for crushing. Notochord persistent, vertebræ not more than rings. Fin-rays robust, fulcra large, dorsal fin not extending more than one-half the length of the trunk. Scales rhombic, except occasionally in the caudal region.

Genus **Semionotus** Agassiz.

(Syn. *Ischypterus* Egerton.)

Trunk fusiform. Marginal teeth slender, conical, somewhat spaced, inner teeth stouter; opercular apparatus well developed,

with a narrow arched preoperculum. Ribs ossified. Fulcra unusually large. Paired fins small, dorsal fin large, arising at or behind the middle of the back, and in part opposed to the relatively small anal; caudal fin slightly forked. Scales smooth or feebly ornamented, and the narrow overlapped margin produced at the angles and at the superior border. Flank-scales not more than twice as deep as broad, the dorsal ridge-series of acuminate scales forming a prominent crest. (Woodward.)

The cranial osteology of this genus is much more satisfactorily known than that of *Catopterus,* although information is still lacking in some particulars. The researches of Agassiz acquainted us in a general way with the structure of the head portion in *S. nilssoni,* from the Rhaetic of Sweden (see Plate VI), and in recent years our knowledge has been increased by the studies of E. Schellwien, Stromer, Tornquist, and other foreign writers, and by the careful work of Dr. George F. Eaton of Yale in this country. Principal enlightenment has been gained from investigation of *S. nilssoni, bergeri, capensis* and *agassizii.* The more important cranial features may be briefly indicated as follows:

The membrane bones of the cranial roof form a continuous shield, extending from the snout nearly to the occipital border. The two principal pairs of bones are the narrow and elongate frontals, reaching from the premaxillaries to behind the orbits, and the much shorter parietals in contact with them posteriorly. As a rule these pairs are not quite bilaterally symmetrical, but the sutures are more regular than in some other members of the same family. Skirting the lateral borders of the frontals, and extending also over the forward part of the parietals, are deep mucous canals, which are developed on the cerebral side of the bones, and hence not commonly visible in the outer aspect. Behind the parietals occur a pair of wedge-shaped plates corresponding to the supratemporals of Palæoniscoids. These are followed in turn by the squamose posttemporals, which in most species resemble the like-named parts in primitive Chondrosteans.

The squamosal is a plate of variable width and irregular shape abutting against the parietals and frontals. It is terminated anteriorly by a ring of circumorbitals, but its posterior limits are apparently not the same for all species. The circumorbitals,

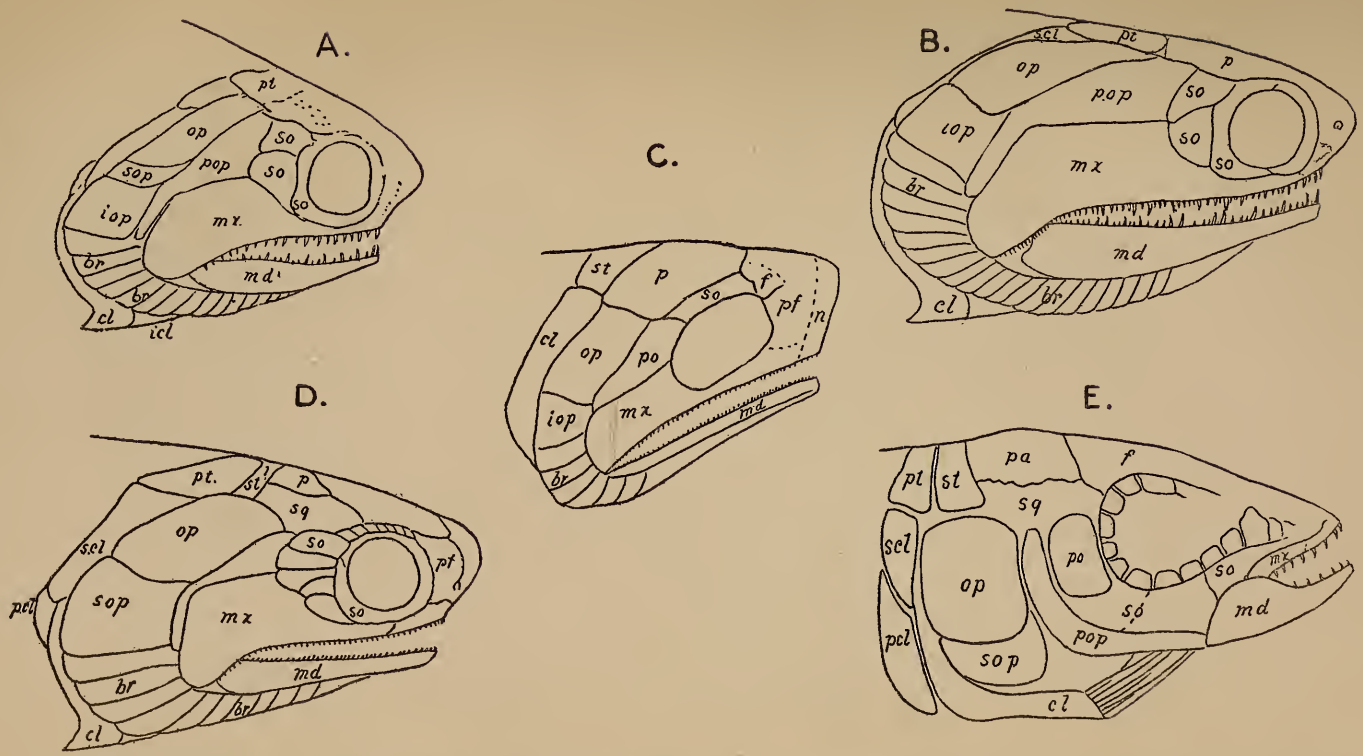

FIG. 7. Comparative Diagrams showing types of cranial structure pre sented by various Paleozoic Chondrosteans (A-D) as contrasted with the Triassic *Semionotus* (E). A, *Rhabdolepis,* Permian (after Traquair). B, *Nematoptychius,* Lower Carboniferous (after Traquair). C, *Rhadinichthys,* Lower Carboniferous (after Tornquist). D, *Palœoniscus,* Permian (after Traquair). E. *Semionotus,* Triassic (after Schellwien).

as their name implies, are a series of small plates surrounding the orbit. They are of polygonal contour (see Fig. 7), and are arranged in much the same fashion as in *Lepidotus,* those along the inferior border being of large size and extending some distance in advance of the upper row. Indications of a mucous canal are observable over part of the circumorbital ring in some species. Immediately below these plates are situated the suborbitals, which are fewer and much larger than in *Lepidotus, Dapedius,* and related genera. The line of demarcation between the suborbitals and contiguous plates has not been satisfactorily determined in any species thus far investigated.[1] The postorbital is a large thin plate situated between the hindermost circumorbitals and the operculum. It is sometimes in contact with the last-named plate posteriorly, as in *S. bergeri* and possibly in *S. nilssoni,* but may be entirely separated from it by the preoperculum, as in *S. capensis.*

The opercular apparatus consists of (1) a large operculum, of variable shape, but generally with a narrower upper border; (2) a narrow, falciform preoperculum, with the mucous canal interrupted and appearing as a series of perforations; (3) a subopercului, the exposed surface of which generally exhibits a sublunate outline; and (4) a triangular interoperculum. The posterior borders of the operculum and interoperculum are embraced by a large and heavy plate, often very conspicuous, the clavicle. This is similar to the preoperculum in form, but is much more solid, and its terminal angle in front is frequently thickened or otherwise prominent. It is succeeded behind by one or two enlarged postclavicular scales. There is a series of branchiostegal rays, but these, like the coracoid, are seldom

[1] Nevertheless, the relations of these plates and also other details of the cranial osteology are shown with considerable clearness, amounting almost to certainty as regards some features, in a number of specimens of *Semionotus* from a locality a few miles north of Guilford, Connecticut. The material referred to was collected nearly a score of years ago by Mr. Loper, and is now preserved in the U. S. National Museum at Washington. Peculiar conditions of weathering, and perhaps also the admixture of much argillaceous matter in the rock, are responsible for the excellent portrayal of details. These specimens suggest an image of what the facial and cranial elements should look like, but the image is blurred, and refuses to shape itself in hard and fast lineaments which are requisite for a dependable restoration. It seems better to resist the temptation to reconstruct the arrangement of head parts from material which is highly suggestive but still not quite decisive. The same applies to well preserved specimens of *Catopterus* from the Connecticut Valley region, and to equally perfect examples of *Perleidus* from the Alpine province.

well preserved, and hence imperfectly known. The nature of the dentition has been sufficiently indicated in the foregoing family and generic diagnoses.

Concerning the use or abandonment of Egerton's generic term *"Ischypterus,"* we shall waste no time in killing dead lions. In this, as in previous articles on American Triassic fishes, the term in question is regarded merely as a synonym of Agassiz's earlier defined genus, *Semionotus.* We pass on now to a consideration of the different species occurring within the New England area.

Semionotus agassizii (W. C. Redfield).

(Plates I, II; Text-figure 8.)

1841. *Palæoniscus agassizii* W. C. Redfield, Am. Journ. Sci., [1] xli, p. 26.

1850. *Ischypterus agassizii* Sir P. G. Egerton, Quart. Journ. Geol. Soc., vi, p. 10.

1856. *Ischypterus marshi* W. C. Redfield, Proc. Amer. Assoc. Adv. Sci., pt. 2, p. 188 (name only).

1888. *Ischypterus agassizii* J. S. Newberry, Monogr. U. S. Geol. Surv., xiv, p. 30, pl. 3, fig. 1.

1888. *Ischypterus marshi* J. S. Newberry, *ibid.*, p. 28, pl. 2, fig. 1.

1903. *Semionotus marshi* G. F. Eaton, Am. Journ. Sci., [4] xv, p. 264, pl. 5, figs. 5, 9, 10, 12; pl. 6, figs. 1, 2.

1905. *Semionotus agassizii* C. R. Eastman, Ann. Rept. N. J. Geol. Surv. for 1904, p. 80, pl. 1; pl. 2, figs. 5, 9, 10, 12; pl. 3, figs. 1, 2; pl. 7, 8.

A large and elegantly fusiform species, attaining a total length to the base of the caudal fin of about 25 cm., in which the length of the head and opercular apparatus is contained three and one-half times. The maximum depth occurs between the paired fins, where the number of longitudinal scale-rows is about twenty. The number of transverse scale-rows, counting along the lateral line, is about thirty-four. Scales everywhere large and thick. The boat-shaped dorsal ridge-scale covering the base of the dorsal fin anteriorly is rather small, rounded in front and not

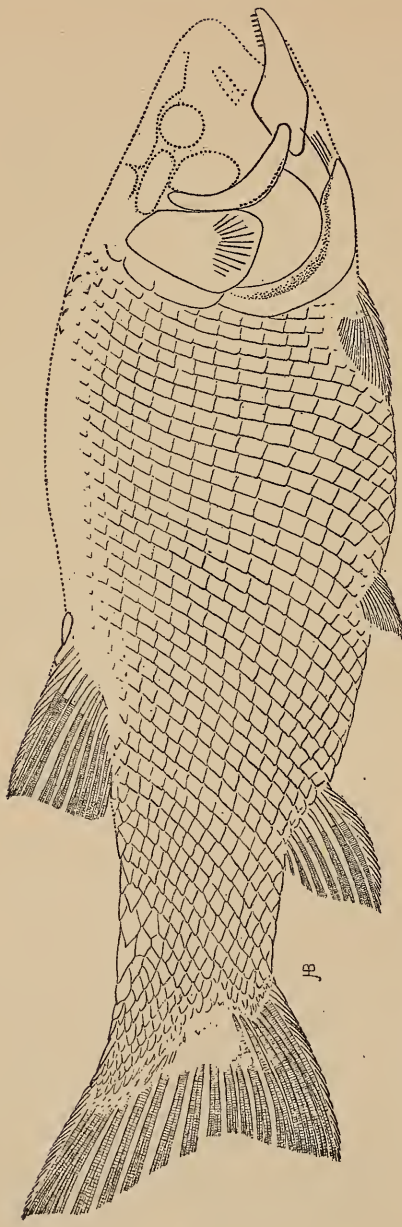

FIG. 8. Semionotus agassizii (W. C. Redfield). Trias; Sunderland, Massachusetts. Lateral aspect of nearly perfect specimen belonging to the American Museum of Natural History, New York. X½.

notched behind, the posterior extremity prolonged instead into a fine point. Fins strong but relatively short-based, the caudal rather prominently furcate and with about seventeen rays. Dorsal, anal, and pectoral fins with about fourteen fulcra each, the ventral with about twelve. Apparently four dorsal fin-fulcra originate on the dorsal line over the basal supports, the fifth being slightly less than one-half the length of the anterior fin-margin. The fin-formula is stated to be as follows:

D. 9-10; C. 17; A. 9; P. 12.

This is one of the largest and most striking of the fossil fishes occurring within the Connecticut Valley region, easily recognized by its gracefully proportioned outline, regular and heavy squamation, and thickness of head bones. Less abundant than either *S. tenuiceps* or *S. fultus* which accompany it, it is distinguished from the former of these by the following differential characters, as was first pointed out by Newberry: the dorsal ridge-scales, which are usually depressed, are less strongly developed than in *S. tenuiceps,* and "the arch of the back does not show the hump which is so characteristic of that species; the fins are very strong; the fulcra of the dorsal and anal fins unusually broad and long, forming arches nearly half an inch wide at the base, curving gracefully backward to a point."

Remains of this species are common to both New Jersey and New England, the locality near Sunderland, Massachusetts, having furnished a number of excellently preserved specimens, including the type of the so-called *Ischypterus marshi.* A photograph of this particular individual is reproduced in Plate I of the present Report, and in Plate II is shown the head portion of the instructive example which served as the basis of Dr. Eaton's restoration, published in 1905. The originals of both plates are preserved in the Peabody Museum of Yale University, and equally perfect and important material is to be found in the American Museum of Natural History at New York. Other interesting specimens are the property of Amherst College and Wesleyan University, respectively. As long ago as 1845, the distribution of this species was stated by J. H. Redfield to be as follows: "Occurs at Sunderland, Mass.; Westfield and Middlefield, Conn.; Pompton and Boonton, N. J."[1]

[1] Quoted by Newberry in his Monograph on Triassic Fishes, 1888, p. 30.

Semionotus fultus (Agassiz).

(Plate III.)

1836. *Palæoniscus fultus* L. Agassiz, Poiss. Foss., ii, pt. 1, pp. 4, 43, pl. 8, figs. 4, 5.
1841. *Palæoniscus fultus* W. C. Redfield, Am. Journ. Sci., [1]xli, p. 25.
1841. *Palæoniscus macropterus* W. C. Redfield, *ibid.*, p. 25.
1847. *Ischypterus fultus* Sir P. G. Egerton, Quart. Journ. Geol. Soc., iii, p. 277.
1850. *Ischypterus fultus* Sir P. G. Egerton, *ibid.*, vi, pp. 8, 10.
1877. *Ischypterus fultus* R. H. Traquair, *ibid.*, xxxiii, p. 559.
1888. *Ischypterus fultus* J. S. Newberry, Monogr. U. S. Geol. Surv., xiv, p. 34, pl. 6, fig. 2; pl. 7, fig. 1.
1895. *Semionotus fultus* A. S. Woodward, Cat. Foss. Fishes Brit. Mus., pt. 3, p. 58.
1901. *Semionotus fultus* E. Schellwien, Phys.-ökon. Gesellsch. Königsberg, p. 29, pl. 3, figs. 4 (?), 5.
1903. *Semionotus fultus* G. F. Eaton, Am. Journ. Sci., [4] xv, p. 261, pl. 5, figs. 1-4.
1905. *Semionotus fultus* C. R. Eastman, Ann. Rept. N. J. Geol. Surv. for 1904, p. 83, pl. 2, figs. 1-4; pl. 9.

The synonymy given above is that adopted by most recent writers. The two species, *S. fultus* and *S. macropterus,* were first united by J. H. Redfield in his paper presented before the American Association of Geologists and Naturalists in 1845, but were afterwards held by Newberry to be distinct on account of slight, and, as a matter of fact, inconstant differences in their body proportions. It is now commonly recognized that minor differences of this nature are the result of accidental conditions of preservation. Following are the chief diagnostic features of this species:

D. 10; C. 15; A. 10; P. 10.

A gracefully fusiform species attaining a total length to the base of the caudal fin of about 15 cm., in which the length of

the head and opercular apparatus is contained three and one-half times. The maximum depth of trunk, which is equal to about one-fourth of the total length, occurs midway between the head and dorsal fin, where there are about twenty longitudinal rows of scales. Scales of lateral line about thirty-three. Dorsal fin arising at mid-length, pectorals nearer to the anal than to the pelvic fins, arising opposite a point directly in advance of the dorsal. Caudal not much forked. Anal with ten rays, partly opposed to hinder half of the dorsal, its origin being on the third oblique scale-row in advance of the dorsal fin. Dorsal fin-fulcra about twelve; anal ten; ventral and pectoral ten each. Apparently four dorsal fin-fulcra originate on the dorsal margin over the interneurals. The fifth dorsal fulcrum has its origin adjacent to that of the first ray, and is about equal in length to one-half the anterior margin of the fin. Scales smooth and not serrated posteriorly, the deepest ones occurring in the fourth row behind the clavicular arch; these are about twice as deep as they are wide in their exposed portion. Dorsal ridge-scales acuminate.

As has been stated, the sole criterion relied upon by Newberry for maintaining the so-called *S. macropterus* as an independent species consisted in a supposed relatively greater depth of body, —"the fusiform and slender fish standing for *I. fultus,* and the broader one for *I. macropterus.*" Curiously enough, it has been shown by Dr. Eaton, after a study of Newberry's originals in the American Museum of Natural History, that, whereas one of the specimens of *S. macropterus* in its compressed and flattened condition is deeper than a type of *S. fultus,* all the others are proportionally more slender.[1] J. H. Redfield, after advocating the suppression of the trivial title *macropterus,* remarks that *S. fultus* is specially characterized by the length of the dorsal and anal fins, which are even longer than in *S. tenuiceps.*[2]

In the New Jersey area, this species outnumbers all others in abundance, and in the Connecticut Valley Trias it is scarcely inferior in numerical importance to the ubiquitous *S. tenuiceps.* The average length of body is stated by Newberry to be about six inches, the maximum rarely exceeding eight inches, including the

[1] *Loc. cit.,* 1903, p. 262.
[2] Cited by Newberry, 1888, p. 35.

caudal fin. In Plate III is given a photographic reproduction of one of the original specimens serving for Newberry's description.

Semionotus tenuiceps (Agassiz).

1836. *Eurynotus tenuiceps* L. Agassiz, Poiss. Foss., ii, pt. 1, pp. 159, 203, pl. 14*c*, figs. 3, 4, 5.
1837. *Palæoniscus latus* J. H. Redfield, Ann. Lyceum Nat. Hist. N. Y., iv, p. 38, pl. 2.
1837. *Eurynotus tenuiceps* J. H. Redfield, *ibid.*, p. 39.
1841. *Eurynotus tenuiceps* E. Hitchcock, Geol. Mass., ii, p. 459, pl. 29, figs. 1, 2.
1841. *Palæoniscus latus* W. C. Redfield, Am. Journ. Sci., [1] xli, p. 25.
1850. *Ischypterus latus* Sir P. G. Egerton, Quart. Journ. Geol. Soc., vi, p. 10.
1857. *Eurinotus ceratocephalus* E. Emmons, Am. Geol., pt. 6, p. 144, pl. 9a.
1860. *Eurinotus ceratocephalus* E. Emmons, Manual Geol., 2d ed., p. 188, fig. 164.
1877. *Ischypterus latus* R. H. Traquair, Quart. Journ. Geol. Soc., xxxiii, p. 559.
1888. *Ischypterus tenuiceps* J. S. Newberry, Monogr. U. S. Geol. Surv., xiv, p. 32, pl. 5, figs. 1-3, pl. 7, fig. 3.
1889. *Allolepidotus americanus* W. Deecke, Palaeontogr., xxxv, pp. 103, 114.
1895. *Semionotus tenuiceps* A. S. Woodward, Cat. Foss. Fishes Brit. Mus., pt. 3, p. 59.
1903. *Semionotus tenuiceps* G. F. Eaton, Am. Journ. Sci., [4] xv, p. 295.
1905. *Semionotus tenuiceps* C. R. Eastman, Ann. Rept. N. J. Geol. Surv. for 1904, p. 87.

A species attaining a total length of about 20 cm., and readily distinguished from all others (except in young stages) by the excessive development of the dorsal ridge-scales; these are very large and conspicuous, and, in mature individuals, comparatively obtuse. The anterior dorsal outline is considerably arched, usually forming a characteristic "hump" immediately behind the head. Length of head and opercular apparatus less than the

maximum depth of the trunk, and contained four times in the total length of the fish. Fins as in *S. fultus*. Scales smooth and serrated, those of the middle of the flank in part twice as deep as broad. The dorsal ridge-scale immediately in advance of the dorsal fin has its posterior border obtuse, and not produced, and the corresponding ridge-scale in front of the anal fin is notched behind. Ribs more strongly developed than in any other species of the genus.

This, the commonest form occurring within the Connecticut Valley area, is as a rule easily determinable, its most conspicuous features being the abrupt elevation of the dorsal outline immediately behind the head, and the spiny appearance of the back occasioned by its being set along the middle with long, thickened, and distally pointed or clavate ridge-scales. The ribs also are more strongly developed than in other species, their curved outlines being sometimes traceable even when covered with scales. Owing to the frequency with which this species has been illustrated, and the impossibility of mistaking it among collections of Triassic fishes, it has not been deemed essential to include a figure of it in the present Report.

S. tenuiceps outnumbers all other species in the Connecticut Valley Trias, and is tolerably abundant also in New Jersey. At Turner's Falls and at Sunderland, Massachusetts, it is especially common, probably more than half of the individuals derived from the latter locality pertaining to this form.

Semionotus micropterus (Newberry).

(Plate IV.)

1888. *Ischypterus micropterus* J. S. Newberry, Trans. N. Y. Acad. Sci., vi, p. 127 (name only).

1888. *Ischypterus micropterus* J. S. Newberry, Monogr. U. S. Geol. Surv., xiv, p. 31, pl. 4, figs. 1, 2; pl. 12, fig. 2.

1893. *Ischypterus newberryi* S. W. Loper, Pop. Sci. News, March 18, and Pop. Science, May, 1899, p. 98.

1903. *Semionotus micropterus* G. F. Eaton, Amer. Journ. Sci., [4] xv, p. 263, pl. 5, figs. 6-8, 11, 13.

1905. *Semionotus micropterus* C. R. Eastman, Ann. Rept. N. J. Geol. Surv. for 1904, p. 87, pl. 2, figs. 6-8.

D. 8; C. 15; A. 8.

A regularly fusiform species attaining a total length to the base of the caudal fin of about 20 cm., the maximum depth occurring shortly behind the pectoral fins and amounting sometimes to nearly one-half the total length. The dorsal and ventral contours are more strongly arched than in *S. fultus,* but the relative position and size of the fins are about the same for both species. Dorsal, anal, and pectoral fin-fulcra relatively shorter than in *S. fultus.* Apparently three dorsal fin-fulcra originate on the dorsal line over the interneurals. The fifth dorsal fulcrum has its origin on the anterior margin of the anterior ray at a considerable distance from its base, and is about one-third as long as the anterior fin-margin. Pectorals with upwards of twenty fulcra. Ridge-scales moderate, spiniform, the one immediately in advance of the dorsal fin slightly produced into a point behind. Scales frequently serrated, those below the lateral line on the flanks tending to become bi- or tridentate on the postero-inferior angle.

This is a deeper-bodied species than any thus far considered, its rather strongly convex outline marking a transition between the types presented by *S. fultus,* for instance, and *S. ovatus.* Indeed, the approach to the last-named species in this respect is sometimes so close as to make a rigid distinction difficult without the aid of other characters. In the case of the specimen selected for illustration in Plate IV, Newberry himself appears to have been in doubt whether to refer it to *S. micropterus* or *S. ovatus,* but finally decided in favor of the former, as shown by MS. records accompanying the original. The most reliable means for identifying the present species is furnished by fin characters, the details of which have been carefully worked out by Dr. Eaton in his paper of 1903, and are incorporated in the above definition.

Remains of this species are fairly abundant in the Connecticut Valley Trias, and show considerable variation of size; that is to say, young individuals occur somewhat numerously, so that gradations may be traced up to the maximum recorded by Newberry. He states that the largest individuals known to him attain a length of ten and one-half inches, and the smallest are "only about three and one-half inches long." Corresponding with the last given dimension, and otherwise agreeing with the characters of this species, is the holotype of the late Mr. S. Ward

Loper's *Ischypterus newberryi.* The peculiarity to which Mr. Loper has called attention, namely, fine concentric scale-markings, seems to have been occasioned by some form of chemical corrosion which has exposed the growth lines. A parallel instance has already been noticed in the case of *Catopterus ornatus* (*supra,* p. 55), and similar conditions are prevalent among fishes of the English Chalk. The original of Mr. Loper's description is of interest for showing a well preserved mandible beset with numerous slender teeth, and a very strongly developed support for the dorsal and anal fins. It is preserved in the Museum of Wesleyan University, and was obtained by Mr. Loper from the anterior shale near North Guilford, Connecticut.

This species is not known to occur elsewhere than within the state of Connecticut, and is especially abundant in the vicinity of Durham. It is possible that the detached head figured by Dr. E. Schellwien in Plate 3, Fig. 4 of his memoir above cited belongs to *S. micropterus,* since this is one of the few species in which the cheek plates are granulated.

Semionotus ovatus (W. C. Redfield).

1842. *Palæoniscus ovatus* W. C. Redfield, Am. Journ. Sci., [1] xli, p. 26.
1847. (?) *Tetragonolepis* Sir P. G. Egerton, Quart, Journ. Geol. Soc., iii, p. 277.
1850. *Ischypterus ovatus* Sir P. G. Egerton, *op. cit.* vi, p. 10.
1888. *Palæoniscus ovatus* J. H. Redfield (quoted by Newberry), Monogr. U. S. Geol. Surv., xiv, p. 27.
1888. *Ischypterus ovatus* J. S. Newberry, loc. cit., p. 27, pl. i, fig. 1.
1903. *Semionotus ovatus* G. F. Eaton, Am. Journ. Sci., [4] xv, p. 266.
1905. *Semionotus ovatus* C. R. Eastman, Ann. Rept. N. J. Geol. Surv. for 1904, p. 78, pl. 4-6.

A large species attaining a total length of about 20 cm., with trunk very much deepened midway between the head and dorsal fin. Scales large and thick, becoming gradually deepened toward the middle of the flanks; tail strong and considerably expanded. Number of dorsal and anal fin-fulcra greater than in any other

species, each fin having sometimes twenty or more. Length of the longest fulcrum of the dorsal fin nearly equalling one-half that of the anterior margin of the fin.

In the original description of *S. ovatus* by William C. Redfield, it is stated that "it exceeds all the known American species in the comparative width or roundness of its form, and is also remarkable for the large size of its scales. It is of rare occurrence, and, owing probably to its great thickness, is seldom obtained in a perfect form." The younger Redfield, commenting on the same species in 1854, pronounced it "the broadest and most ovate species of *Palæoniscus* that is known," and added further, that "in size of the scales it resembles *P. Agassizii,* but its form will readily distinguish it." That is to say, the squamation is heavy, but the flank-scales are relatively deeper than in *S. agassizii,* and the form is also deeper-bodied, or more ovate.

The Redfields, father and son, and also Newberry, agree in claiming for this species a distribution in both the Connecticut Valley and New Jersey Triassic basins. With this species Newberry also identifies a fragmentary individual from the Triassic Coal-field of Virginia, originally referred to *Tetragonolepis* by Sir Philip Grey Egerton. Noteworthy is the fact that all the more perfect examples have been obtained from a single locality near Boonton, New Jersey, and the recognition of this species in outlying areas depends upon the evidence of unsatisfactory material. The present writer has thus far failed to discover a single undoubted example of the species in question from the Connecticut Valley Trias, yet this is by no means equivalent to saying that its remains do not occur in this region. It may perhaps be worth mentioning that in the Museum of Wesleyan University is preserved the anterior half of a deep-bodied fish (Cat. No. 869) whose specific relations cannot be accurately determined. It is labeled as belonging to *S. gigas,* a "species" which can be maintained only in a provisional sense. The so-called *Semionotus robustus* of Newberry is but little better known, and is doubtfully distinct from *S. ovatus,* which it approximates in size. A certain resemblance between the published figure of *S. robustus* and the imperfect deep-bodied specimen at Wesleyan University just referred to cannot be denied. Further evidence, however, is necessary before we can positively affirm the presence of *S. ovatus* in the New England area.

Extra-limital Species of Semionotus.

At least three other valid species of *Semionotus,* besides those already enumerated, have been described from the Trias of Eastern North America. These are, *S. lineatus, elegans,* and *brauni* of Newberry. They are all confined to the New Jersey area, so far as known, and the last-named is from the very base of the Trias in that state, being separated from the Boonton horizon by an interval of several thousand feet. The limits set to the present Report do not admit of elucidating the characters of these species, which can by no possibility be confused with the members of our local fauna. Nevertheless, it has been thought desirable to offer an illustration of the form which has been appropriately named *S. elegans* by Newberry (Plate V), and also to show the head-portion of the type specimen of *S. nilssoni* (Plate VI), which enabled Agassiz to decipher the main elements of the cranial structure of this genus.

To the list of imperfectly defined or doubtful species, the status of which is merely provisional, must be added the names of the so-called *Ischypterus parvus,* founded upon a figure published in Hitchcock's Geology of Massachusetts, in 1835; *Ischypterus minutus* Newberry, from Durham, Connecticut; and *Ischypterus beardmorei* Smith, from Boonton, New Jersey. Of uncertain position also are the obscure remains of a Semionotus-like form described by Newberry under the name of *Acentrophorus chicopensis,* the few known examples of which have been obtained from metamorphosed sandy shales near Chicopee Falls, Massachusetts.

It will be convenient to notice at this point the status of an imperfectly known European form, described in the first instance by Deecke as a species of *Semionotus,* and recently made the type of a distinct genus (*Perleidus*) by De-Alessandri, who places it in association with the Catopteridæ. The type species, *P. altolepis* (Deecke), occurs in the Ladinian beds of Perledo, Lombardy, and the original specimen upon which it is founded is preserved in the Senckenbergian Museum at Frankfurt. Deecke, in describing the species, remarked that it appeared to him to denote a transitional stage between the genera *Semionotus* and *Pholidophorus.* Schellwien, who later examined the specimen, doubted whether it could properly be included in the genus

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Semionotus, but did not attempt to fix its systematic position more precisely.

The reasons which in Professor De-Alessandri's opinion justify a removal of this species, and with it the new genus *Perleidus,* to the group of Catopterids, are enumerated by this author as follows: "The arrangement of the cranial elements, the form of the maxilla, especially its expanded posterior portion, the absence of suborbital plates, and the presence of a large-sized postorbital, compel an assignment of this form to the family of Catopteridæ, and make it necessary for us to regard it as the type of a new genus. Moreover, the position and form of the fins, the rather feeble fulcra, the configuration of the scales with their strongly denticulated posterior border, and the absence of a series of acuminate dorsal ridge-scales, are characters which warrant a separation from the genus *Semionotus.*"[1]

The new genus *Perleidus* is thus diagnosed by its founder: "Trunk elongate-fusiform, and head relatively small. Superficial ornament of the cranial plates consisting of rather fine tuberculations and rugæ. Maxilla extended, and posteriorly enlarged. A series of circumorbitals present, but no suborbitals; one large postorbital plate present. Fins moderately developed, comprising robust articulated rays; fulcra small. Dorsal fin situated opposite the pelvic pair; caudal slightly forked. Scales rhomboidal, deeper than long, smooth on their exposed portion, their posterior border denticulated."[2]

That the above-mentioned genus is well characterized there can be no doubt, and the reasons for excluding it from association with *Semionotus* are sufficiently valid. It must be admitted, however, that the form in question presents considerable resemblance to *Pholidophorus,* and the position of the dorsal fin, which arises in advance of the anal, offers a marked contrast to the condition observed in the family Catopteridæ, from which condition indeed is derived the name of the typical genus. We prefer to accept the Milanese author's determination of the family position of this genus in a provisional sense, rather than to assign it elsewhere without having had opportunity to study the actual specimens.

[1] Studii sui Pesci Triasici della Lombardia. *Mem. Soc. Ital. Sci. Nat.,* 1910, vii, p. 51.

[2] *Loc. cit.,* p. 49.

Family EUGNATHIDÆ.

Trunk fusiform or elongate, not much laterally compressed. Cranial and facial bones moderately robust, externally enameled, and opercular apparatus complete; gape of mouth wide, snout produced, marginal teeth conical and larger than the inner teeth. Fin-rays robust, articulated, and distally divided; fulcra conspicuous. Dorsal fin short and acuminate. Scales rhombic, sometimes with rounded posterior angles.

Genus **Ptycholepis** Agassiz.

Trunk elegantly fusiform; snout acutely pointed and prominent; external bones highly ornamented with prominent waved ridges; marginal teeth very small and regular; dorsal fin in advance of anal, caudal fin forked; scales all narrow and elongate, marked with deep longitudinal grooves. Fulcra biserial, conspicuous on all the fins excepting the dorsal.

Ptycholepis marshi Newberry.

(Plates VII, VIII.)

1878. *Ptycholepis marshi* J. S. Newberry, Ann. N. Y. Acad. Sci., i, p. 127.

1888. *Ptycholepis marshi* J. S. Newberry, Monogr. U. S. Geol. Surv., xiv, p. 66, pl. 19, figs. 1, 2.

1895. *Ptycholepis marshi* A. S. Woodward, Cat. Foss. Fishes Brit. Mus., pt. 3, p. 324.

1905. *Ptycholepis marshi* C. R. Eastman, Ann. Rept. N. J. Geol. Surv. for 1904, p. 100.

1908. *Ptycholepis marshi* L. Hussakof, Bull. Am. Mus. Nat. Hist., xxv, p. 95.

A species of slender proportions, attaining a length of about 20 cm. Head with opercular apparatus occupying somewhat more than one-fourth the total length of the fish. Ornamental rugæ of cranial roof slightly radiating; those of the facial and opercular plates more or less parallel and forked. Dorsal fin far forwards, and pelvic fins arising opposite its hinder extremity. Scales exhibiting only longitudinal ridges and furrows, and the hinder border often deeply serrated. (Woodward.)

This gracefully formed and elaborately ornamented species is known by a dozen or more examples, all derived from a single locality near Durham, Connecticut. Among these are several excellently preserved individuals, including the type shown in Plate VII, material which might be expected under ordinary circumstances to yield valuable enlightenment concerning cranial structure. Progress in this direction, however, is subject to the limitations imposed by the peculiar nature of the head bones themselves: that is to say, by the highly sculptured and heavily enameled outer surface which completely conceals suture lines. It is nevertheless permissible to draw certain inferences concerning the extent and arrangement of plates forming the cranial roof by noting the centers of radiation and territory traversed by the superficial radiating rugæ; and the general pattern thus revealed has been found to agree with typical Eugnathidæ. The dorsal aspect of the cranial roof, together with some of the facial bones and opercula, is favorably exposed for study in the specimen represented in Plate VIII, the original being preserved in the Yale Museum (Cat. No. 2608). The lateral aspect is even more favorably shown in the original of Plate VII, which is the property of Wesleyan University Museum (Cat. No. 907). This example, though of a young individual, is admirable for its presentation of fin and scale structure, and for showing the normal body contour.

In connection with the distribution of this form, it should be recalled that its accompaniment by *Semionotus, Catopterus* and a Crossopterygian genus (*Diplurus*) is a fact of capital importance in assigning the fauna in question to a horizon equivalent to the Upper Muschelkalk and Lower Keuper of the European marine Trias. All the evidence derived from a study of the fossil fishes is in favor of establishing a correlation at a level embracing these two horizons, but probably not extending higher than the basal division of the Keuper in the Mediterranean region.[1] For a recent review of the evidence for establishing an

[1] That is, the Newark fauna cannot be regarded as younger than the faunas of Besano, Lombardy, and of Raibl, Carinthia (Lower Alpine Keuper), which mark the uppermost range of one of the intercommunal genera *Ptycholepis*. The Upper Muschelkalk (Ladinian) terms of comparison are furnished by two Semionotid genera, one Captopterid, and one Crossopterygian, according to the revised determinations of Professor G. De-Alessandri (1910).

inter-regional correlation of the Trias, based upon another class of remains than fossil fishes, we may be permitted to refer at this point to Dr. J. C. Merriam's elaborate memoir on "Triassic Ichthyosauria, with special reference to American forms" (especially the chapter on Geologic and Geographic occurrence, pp. 12-20).[2] The evidence as to the age of the Triassic formation of eastern North America which is furnished by reptilian remains (*i. e.,* numerous footprints and a few skeletons of Dinosaurs) will be discussed in a forthcoming Bulletin of the Connecticut State Survey by Professor R. S. Lull of Yale University.

In conclusion, the writer of the present article desires to acknowledge his indebtedness and at the same time return hearty thanks to the following named friends and colleagues who have shown him many courtesies and placed numerous facilities at his disposal, thereby greatly aiding the preparation of this Report: Professor William North Rice and the late Mr. S. W. Loper of Wesleyan University; Professor Charles Schuchert and Dr. George F. Eaton of Yale; Professor B. K. Emerson and F. B. Loomis of Amherst; Professor Bashford Dean and Dr. E. O. Hovey of the American Museum of Natural History, New York; and the authorities of the U. S. National Museum at Washington.

[2] *Memoirs of the Univ. of California,* 1908, i, no. 1, pp. 1-196, pl. 1-18.

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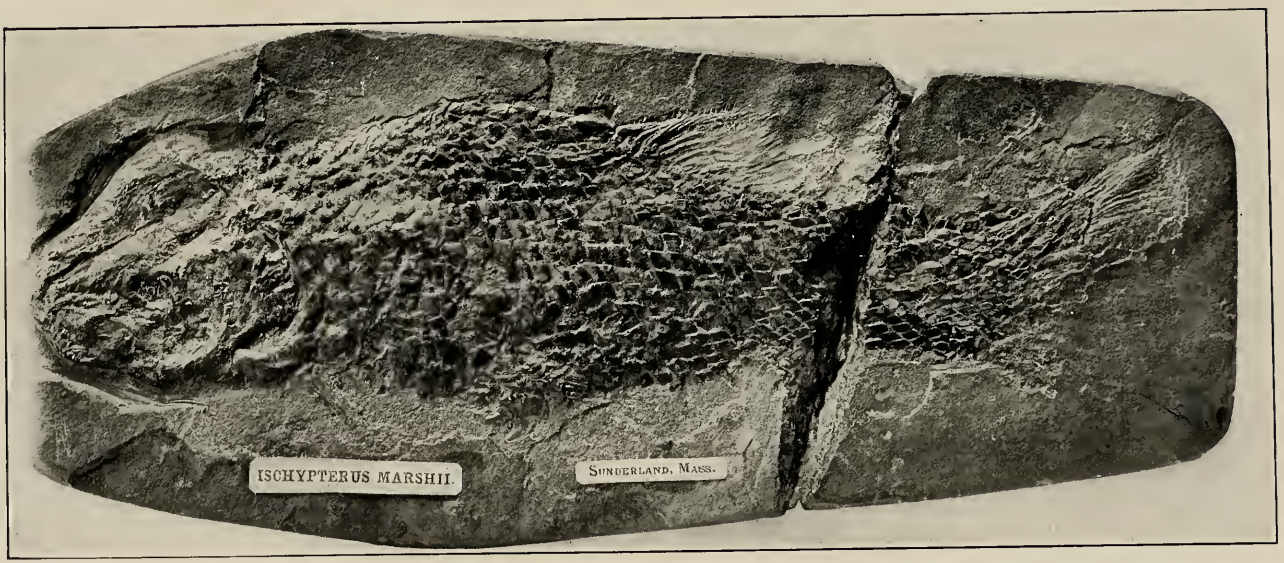
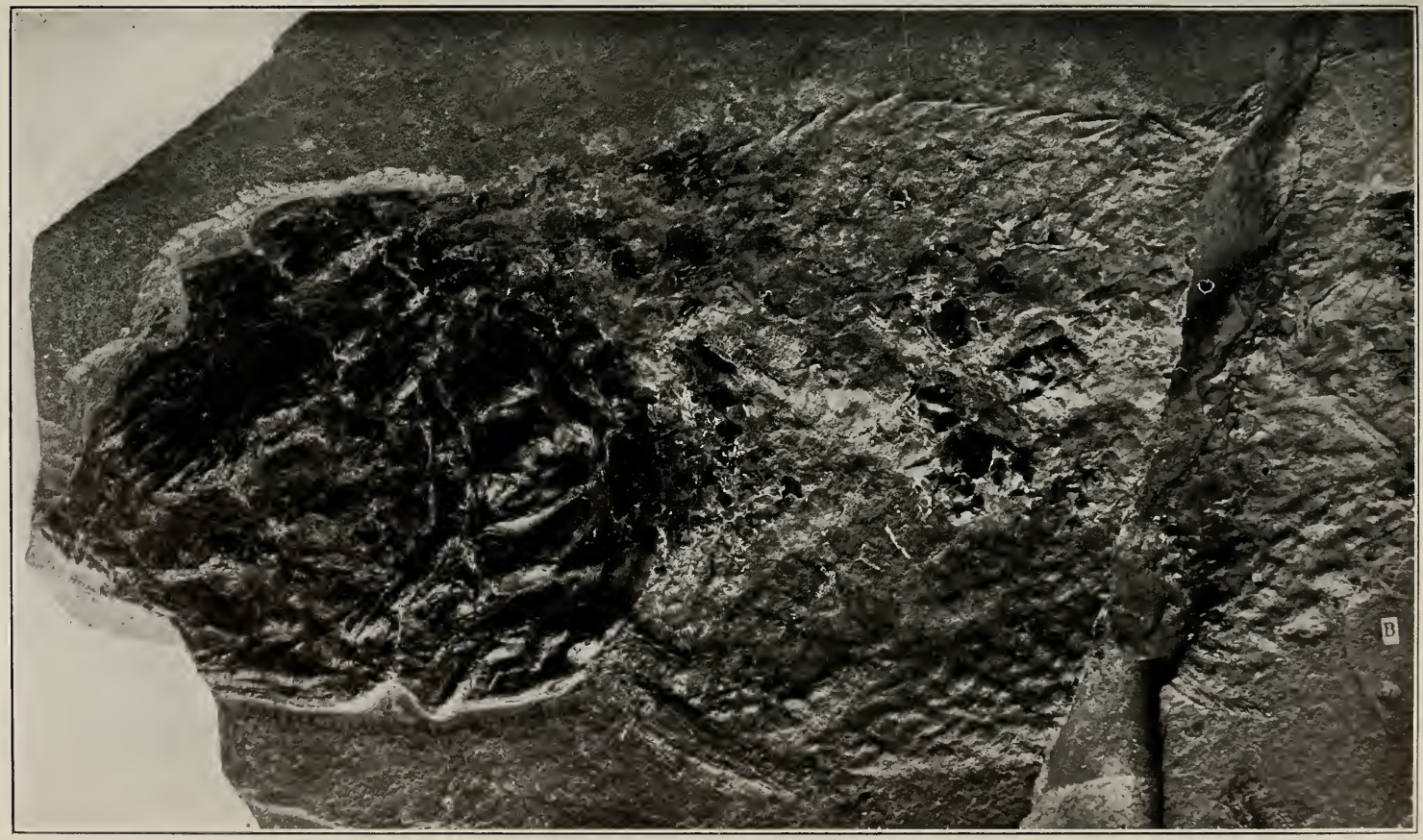
Plate I.

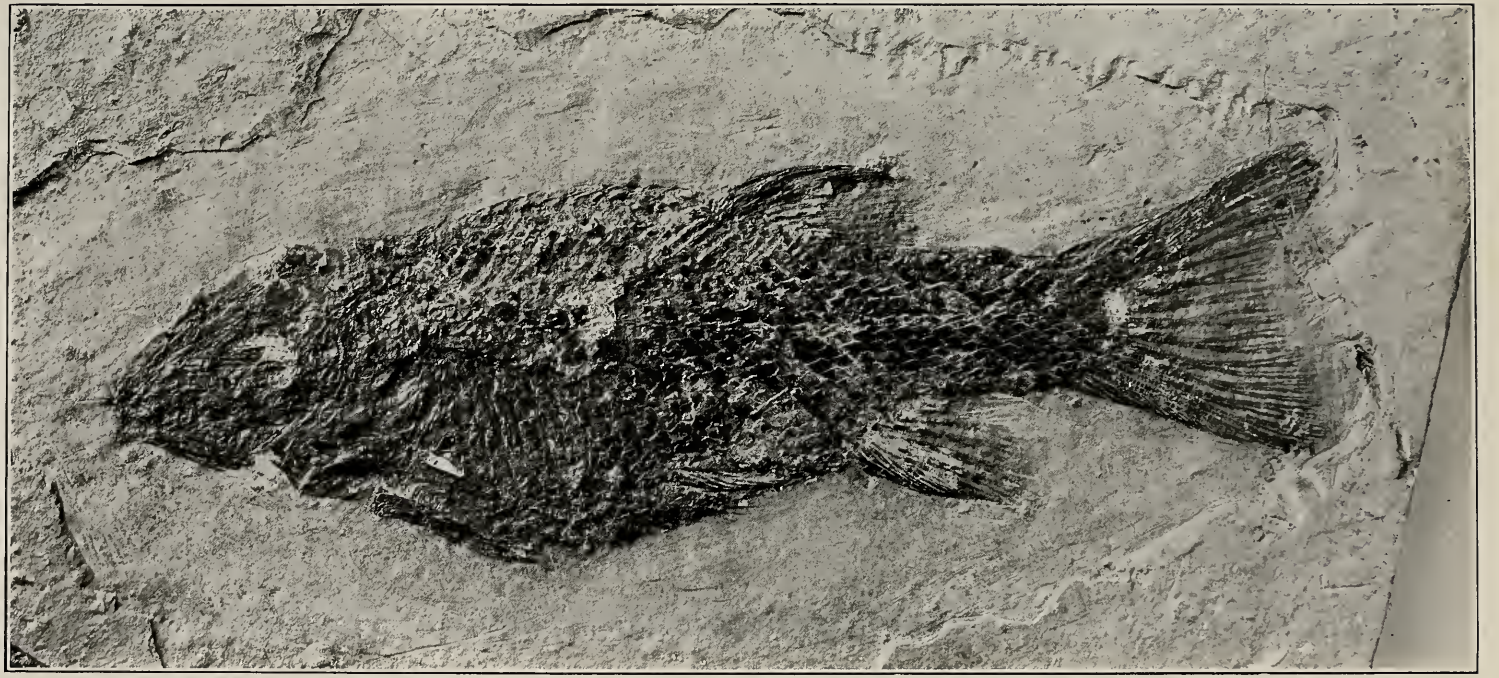


Semionotus agassizii (W. C. Redfield). Trias; Sunderland, Massachusetts. This specimen is the type of Newberry's *Ischypterus marshii*. Original in Peabody Museum of Yale University. × ½.



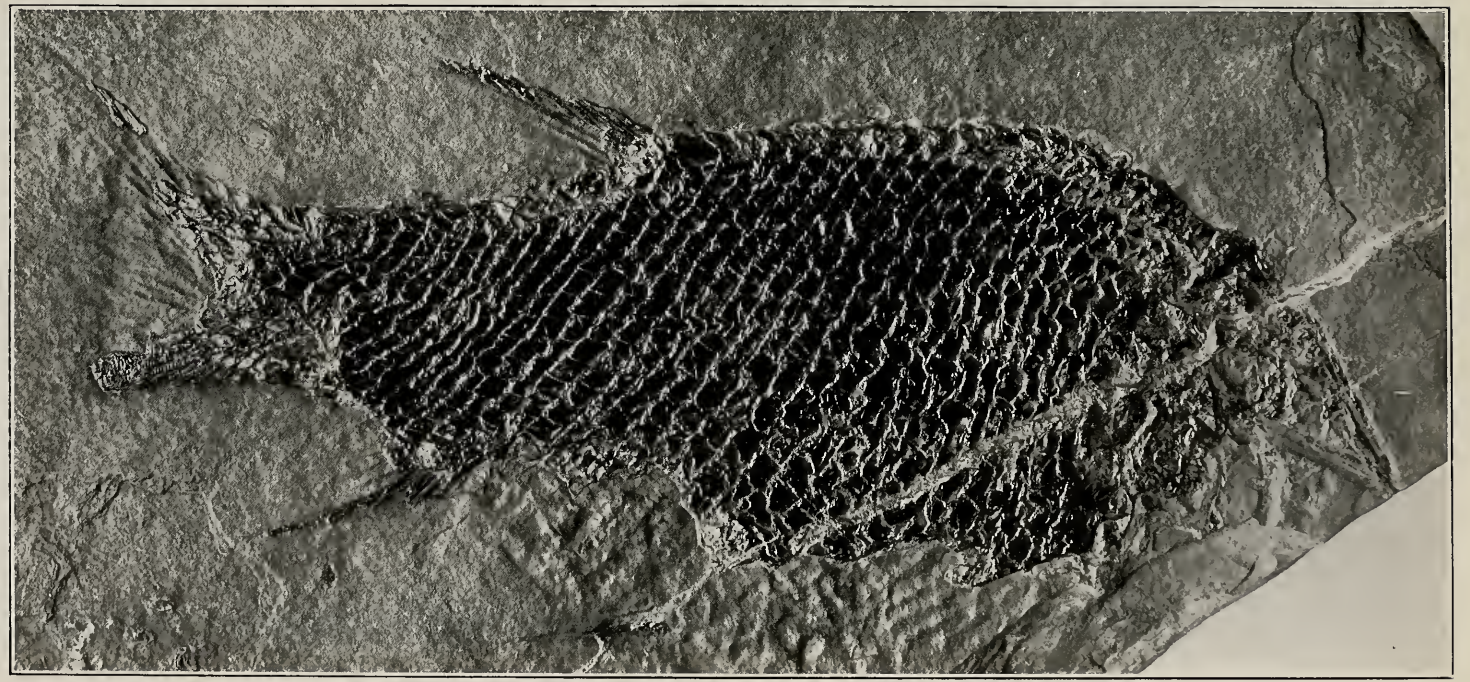
Semionotus agassizii (W. C. Redfield) Trias; Sunderland, Massachusetts. Head and anterior portion of the trunk of a well preserved individual serving as the basis of Dr. Eaton's restoration of the cranial osteology. Original in Peabody Museum of Yale University. × ½.

Plate III



Semionotus fultus (Agassiz). Trias; Boonton, New Jersey. Nearly complete fish, illustrated in Plate 6, Fig. 2, of Newberry's Monograph. Original in American Museum of Natural History, New York. × $\frac{7}{8}$.

Plate IV.

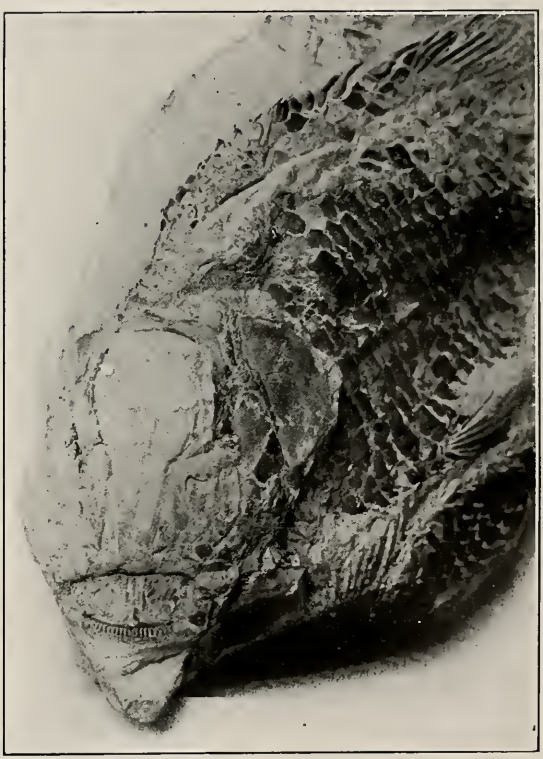


Semionotus microptorus (Newberry). Trias; Durham, Connecticut. Average-sized example, rather imperfectly preserved, showing convex contour of body, regular squamation, and characters of dorsal fin. Original in American Museum of Natural History, New York. ×$\frac{1}{3}$

Plate V.

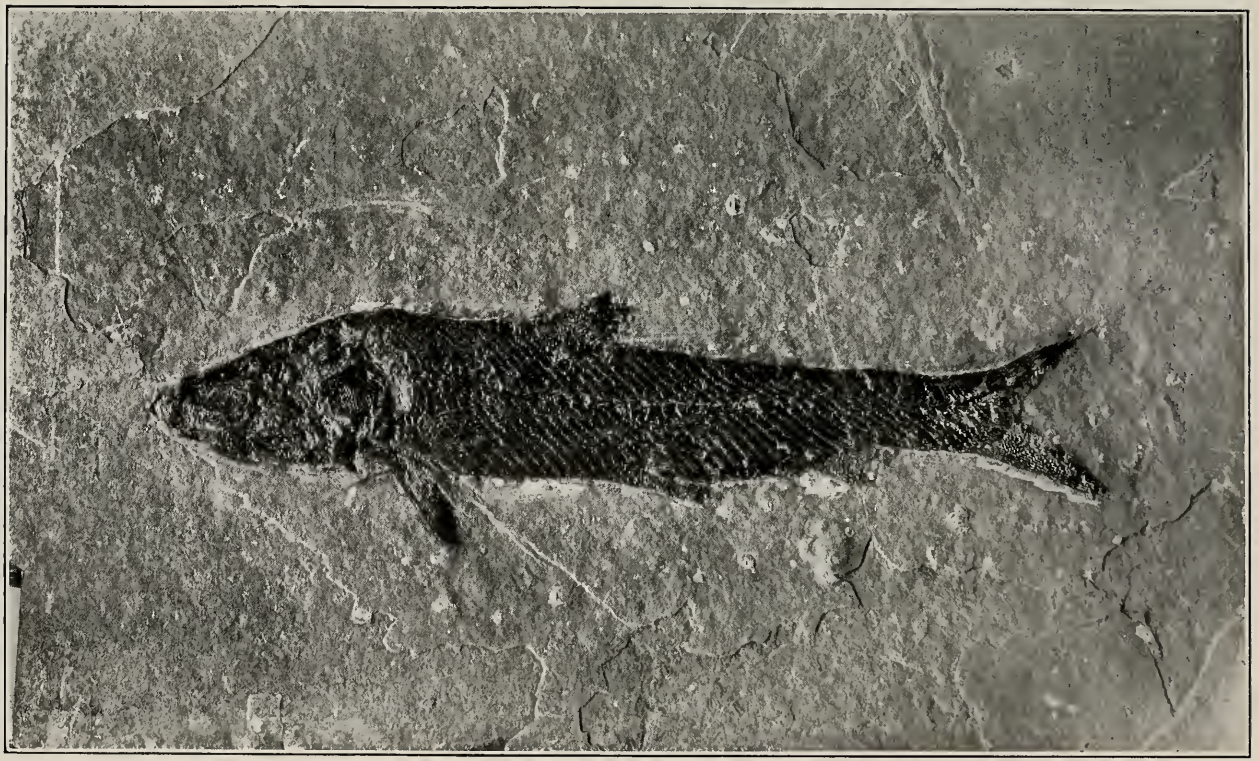
Semionotus elegans (Newberry). Trias; Boonton, New Jersey. Nearly complete fish, illustrated in Plate 14, Fig. 1, of Newberry's Monograph. Original in American Museum of Natural History, New York. $\times \frac{1}{1}$.

Plate VI.



Semionotus nilssoni Agassiz. Rhaetic; Hoegenaes, Sweden. Head portion of holotype, showing cranial plates and dentition. Original in Museum of Comparative Zoology, Cambridge, Massachusetts (Cat. No. 2685). × $\frac{1}{1}$.

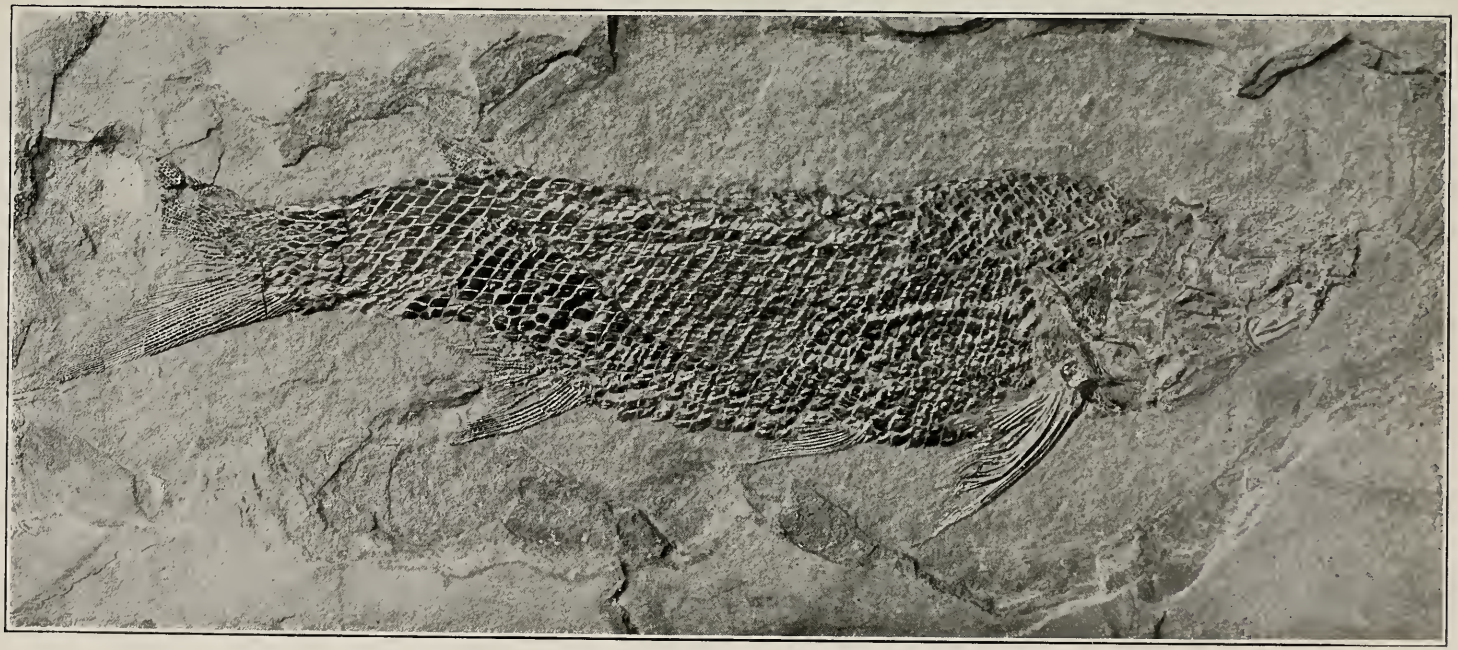
Plate VII.



Ptycholepis marshi Newberry. Trias; Durham, Connecticut Complete fish, illustrated in Plate 19, Fig. 1, of Newberry's Monograph. Original in Museum of Wesleyan University. $\times \frac{1}{1}$.

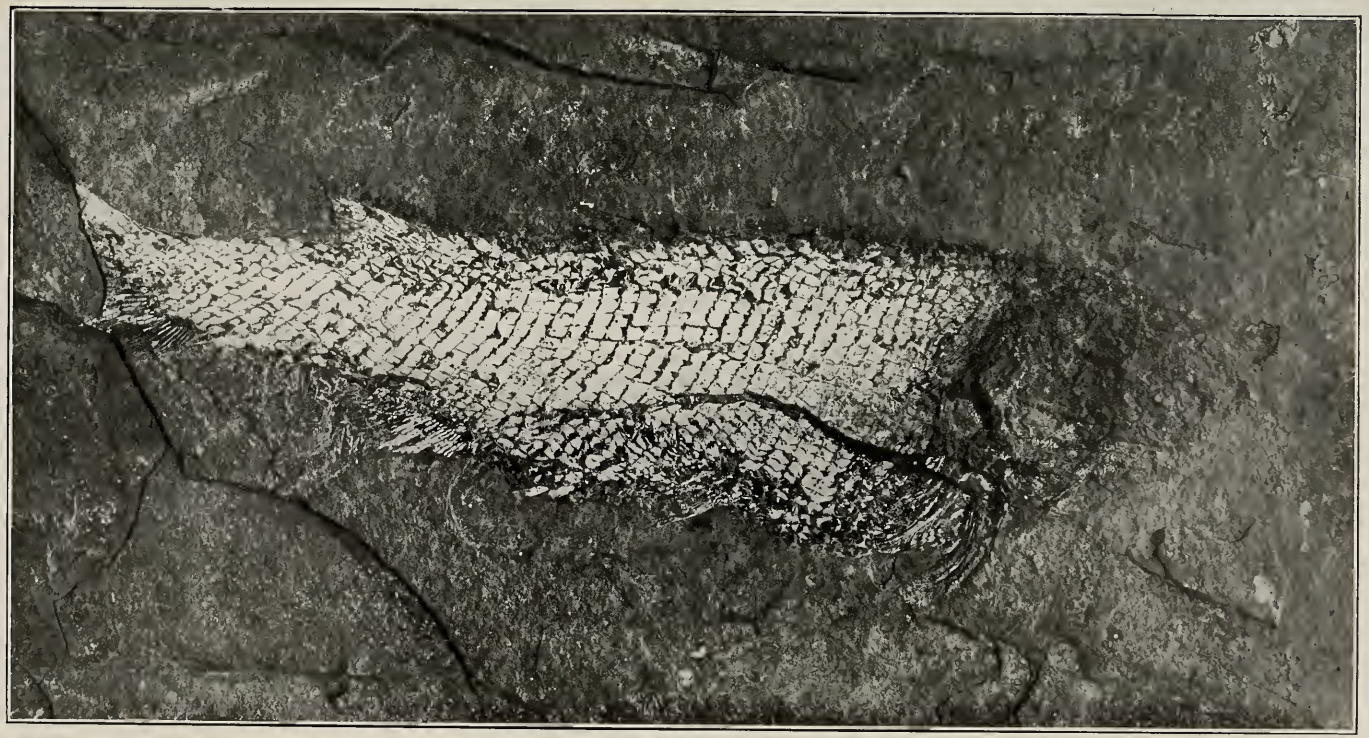
Ptycholepis marshi Newberry. Trias; Durham, Connecticut. Well preserved fish, showing dorsal aspect of flattened-out cranium. Original in Peabody Museum of Yale University. $\times \frac{1}{1}$.

Plate IX.



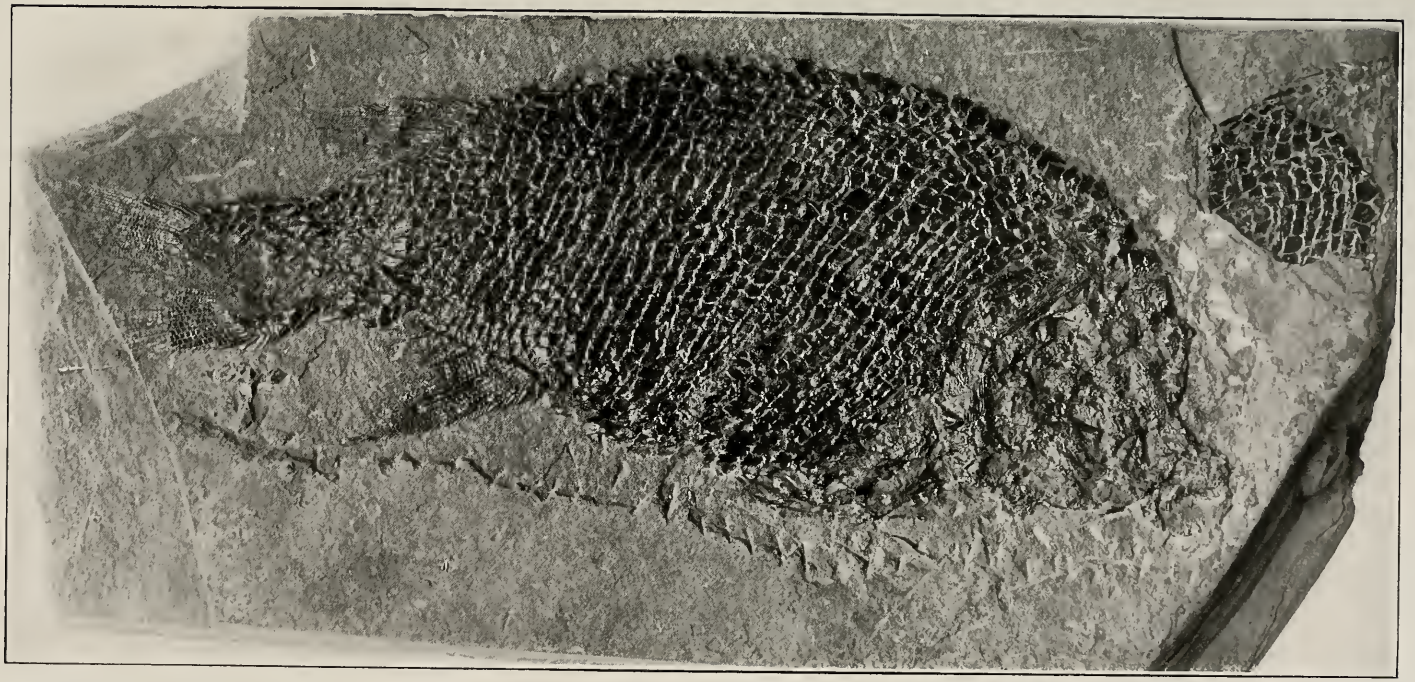
Catopterus gracilis J. H. Redfield. Trias; Sawmill Hollow, four miles southwest of Middletown, Connecticut. Cotype. Original in Peabody Museum of Yale University. × $\frac{5}{6}$.

Plate X.



Catopterus gracilis J. H. Redfield. Trias (Posterior shale); Durham, Connecticut. Nearly complete fish, the only one of this species yet discovered in the uppermost horizon of the Durham section. The whitish appearance of the scales is due to mineral replacement resulting from chemical action upon the enclosing shale. Original collected by S. Ward Loper, and now in the Muesum of Wesleyan University. $\times \frac{3}{4}$.

Plate XI.



Catopterus gracilis J. H. Redfield. Trias; Durham, Connecticut. Original collected by S. Ward Loper, and now in the Peabody Museum of Wesleyan University. × $\frac{7}{8}$.

Gaylord
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